

Test-Driven Development with C#





Somkiat Puisungnoen

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Intro

Software Craftsmanship

Software Practitioner at สยามช่างนาฏกิจ พ.ศ. 2556

Agile Practitioner and Technical at SPRINT3r

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Java and Bigdata



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Slide

<https://github.com/up1/course-tdd-with-dotnet>





Testing in general



Technical excellence



SPECIFICATION BY EXAMPLE



CONTINUOUS
INTEGRATION



CONTINUOUS DELIVERY



TEST AUTOMATION



THINKING ABOUT TESTING



TECHNICAL
EXCELLENCE



TEST-DRIVEN DEVELOPMENT



ARCHITECTURE
& DESIGN



ACCEPTANCE
TESTING



CLEAN CODE



UNIT TESTING

<https://less.works/less/technical-excellence/index>





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CLEAN CODE



UNIT TESTING



**"Program testing can be used
to show the presence of bugs,
but never their absence."**

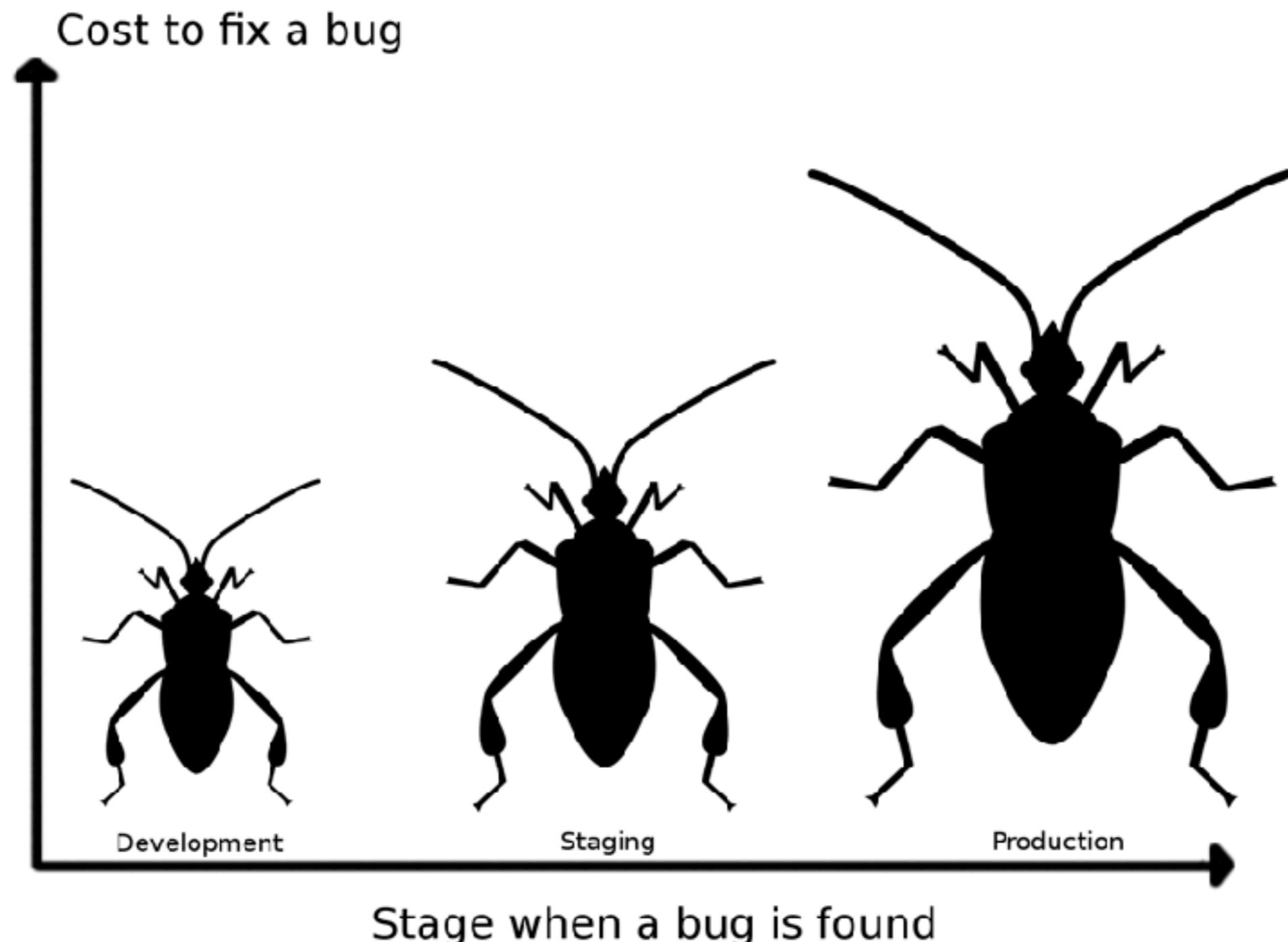
Edsger W. Dijkstra, 1970, Notes on Structured Programming

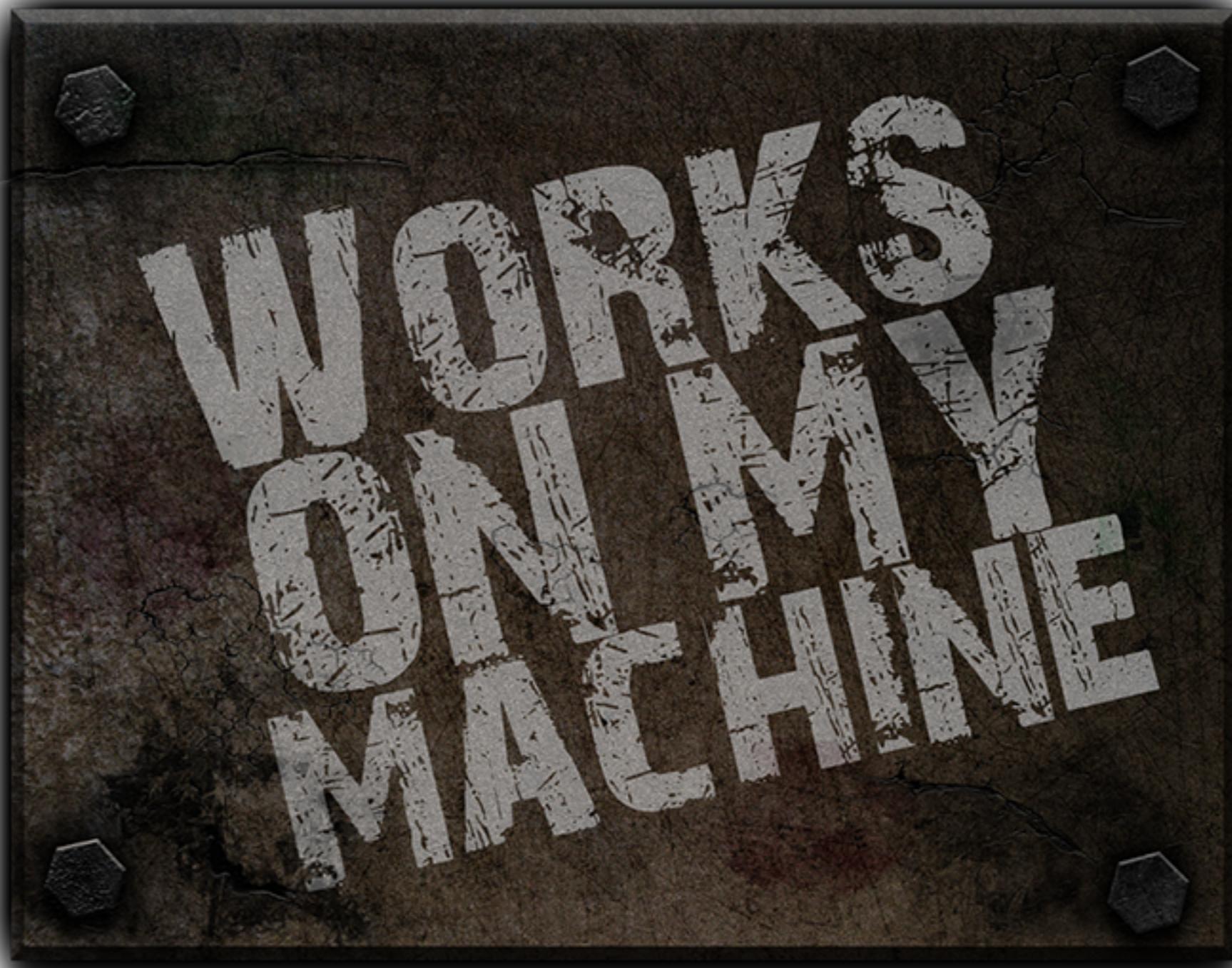


Start with Why ...







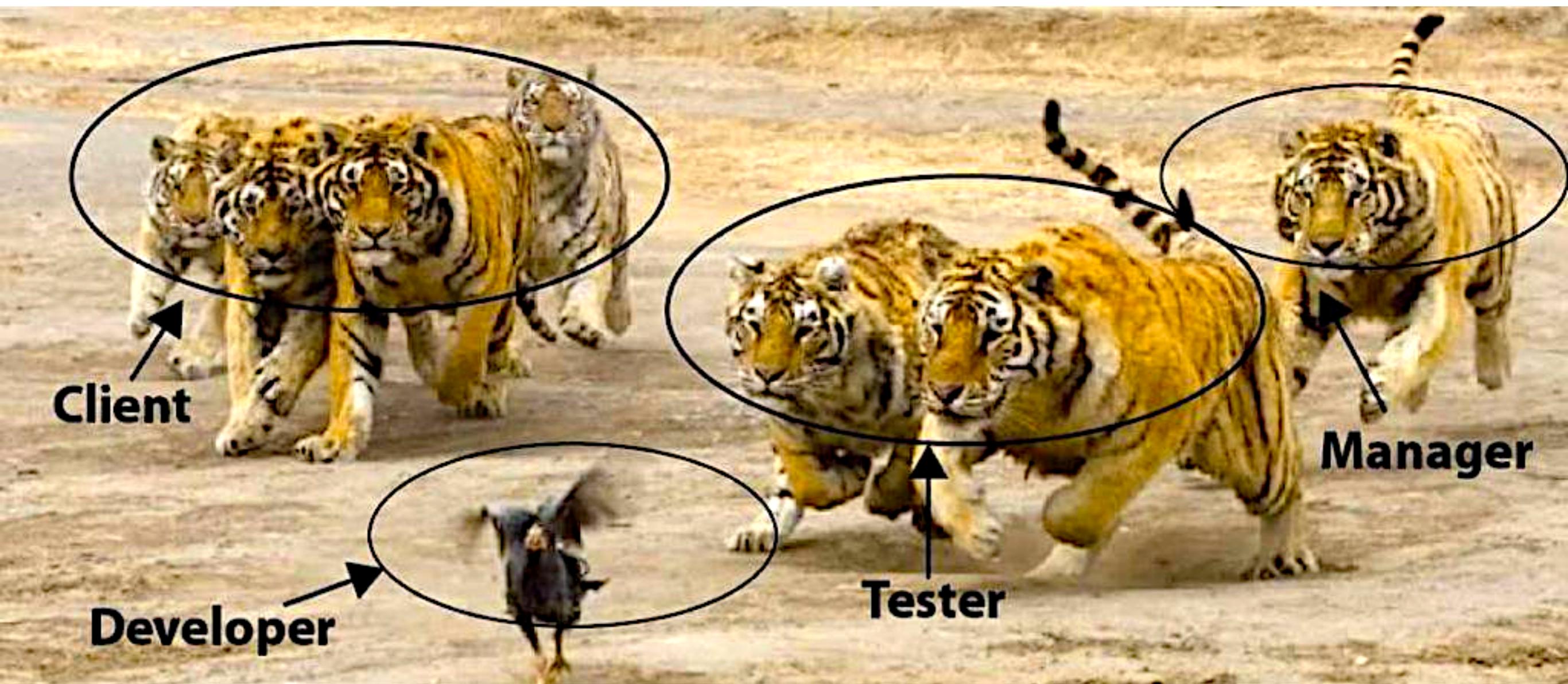


DDD

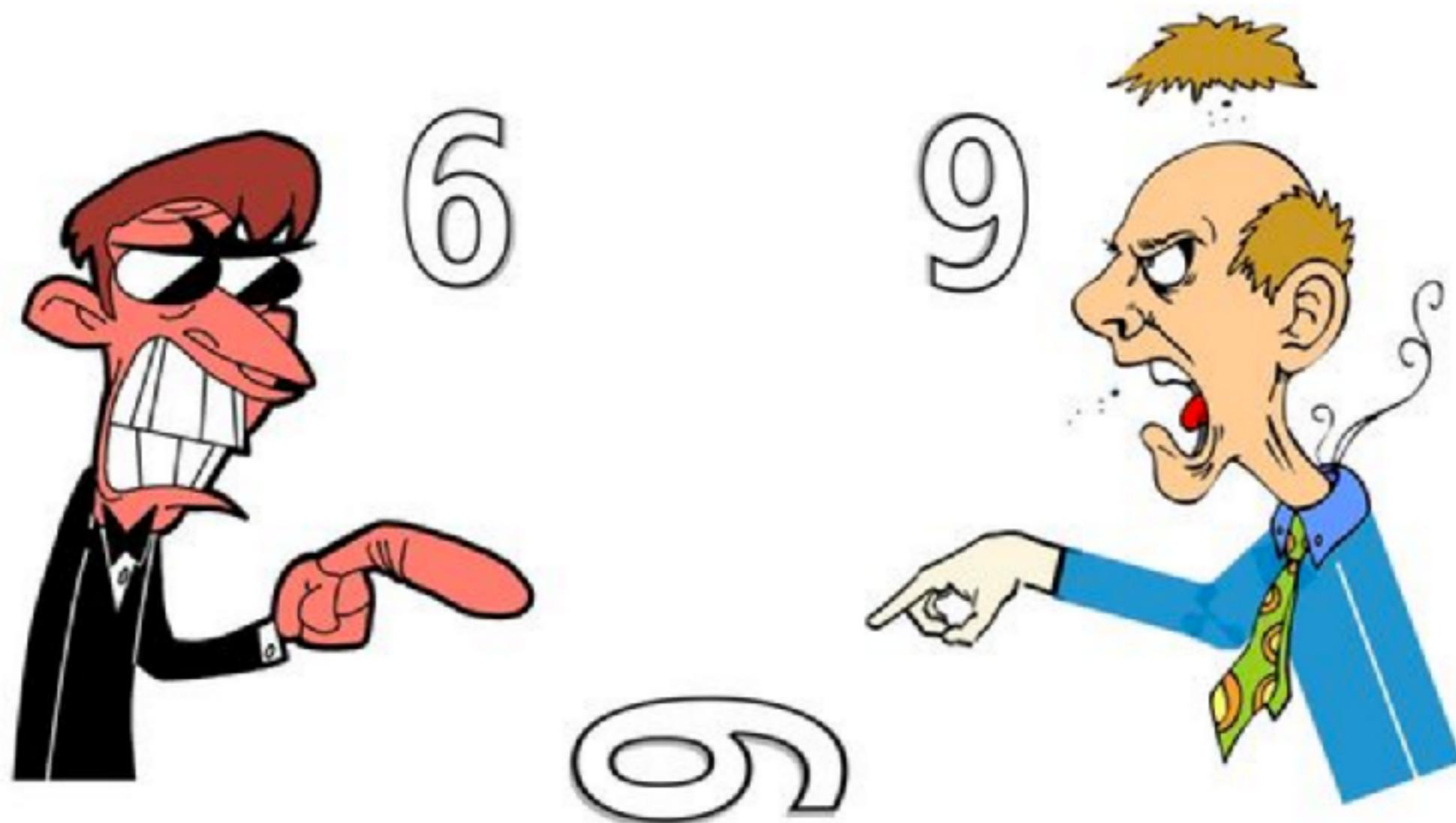


Deadline Driven Development





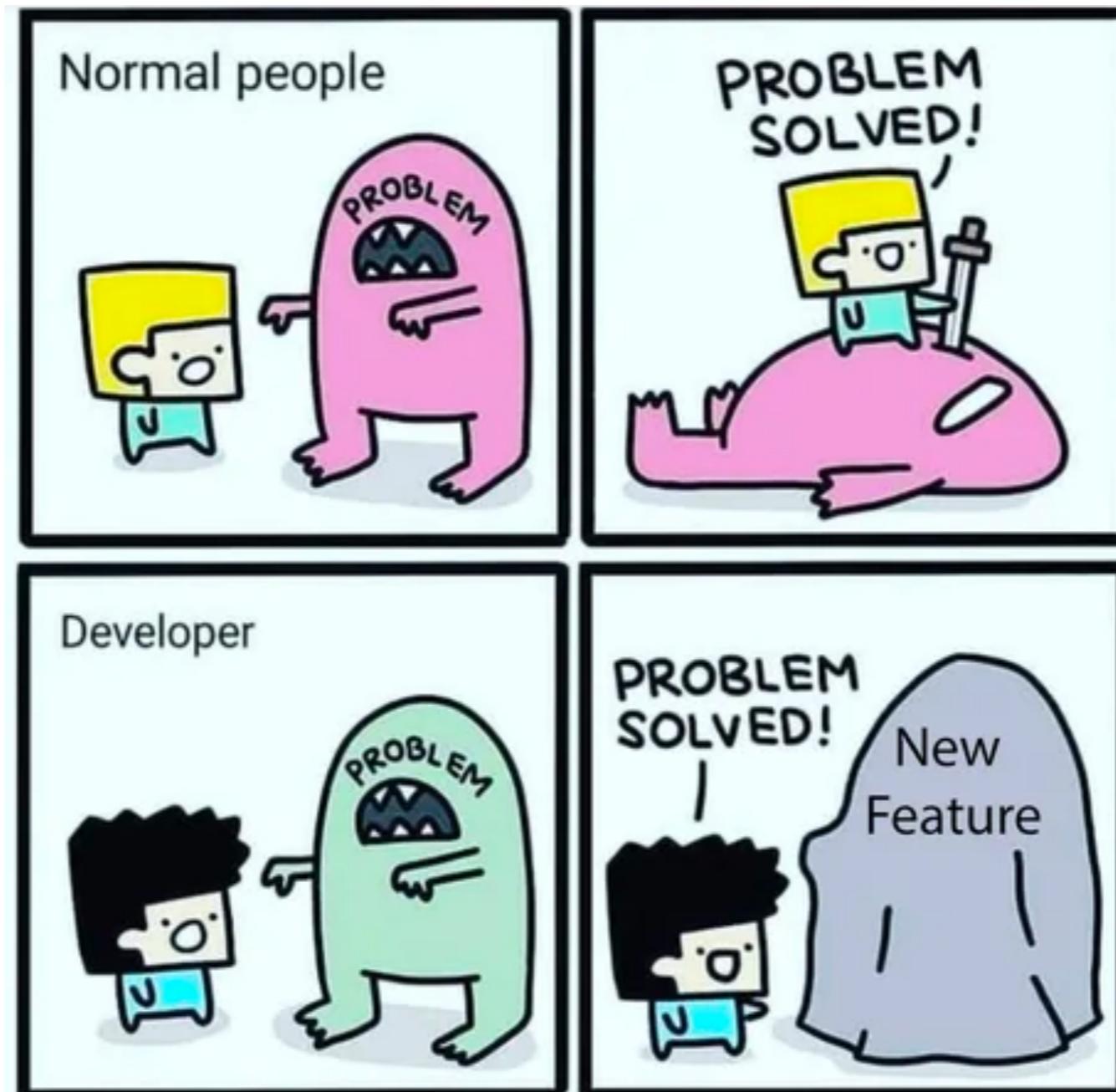
Developer vs Tester





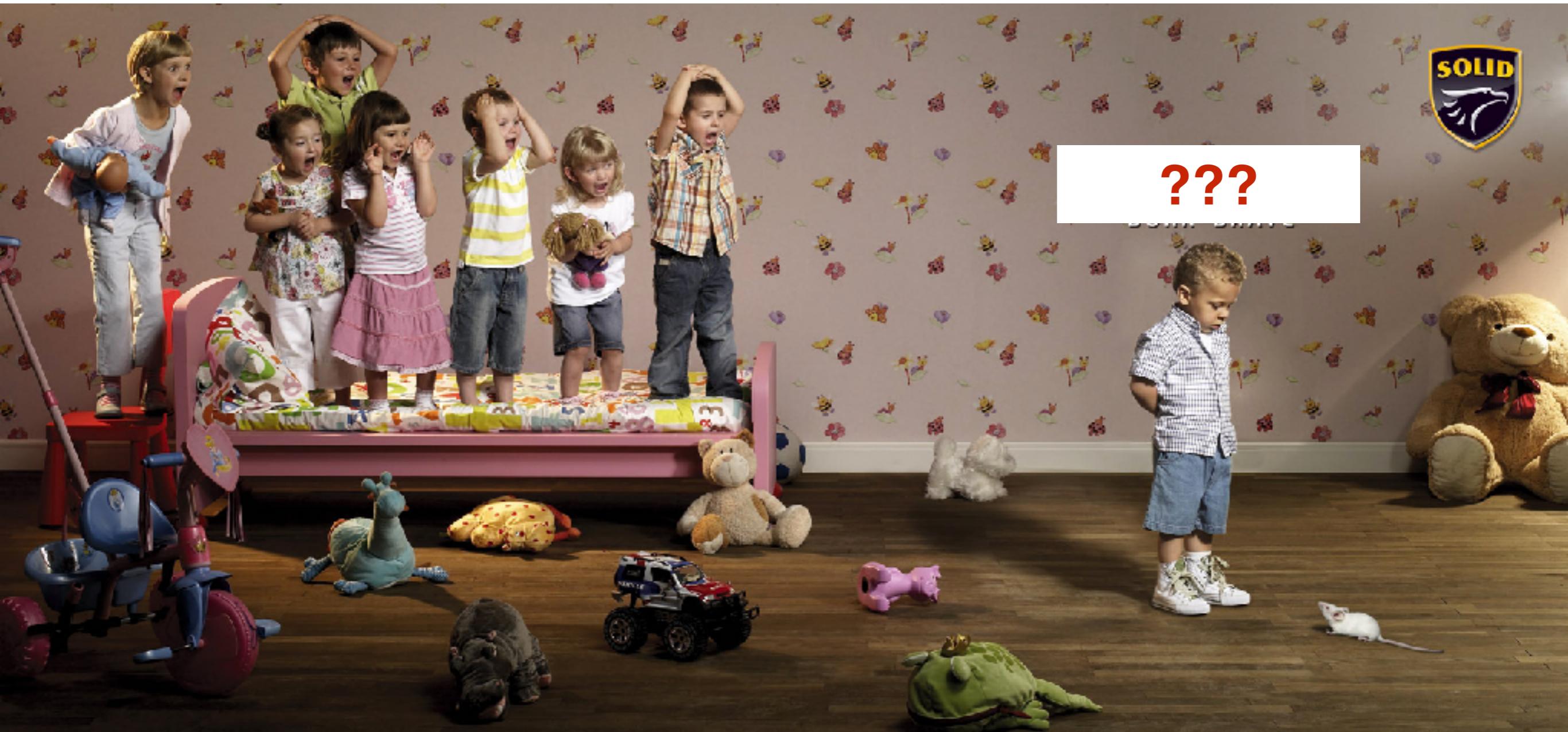
www.cartoonistshilpa.com





Every time a developer changing the code !!







TONIGHT WE TEST

IN PRODUCTION!!!

memegenerator.net



Why we need to test ?

Help you to **catch bugs**

Boosted confidence

Quality code

Enforce **modularity** of your project

Develop features **faster**

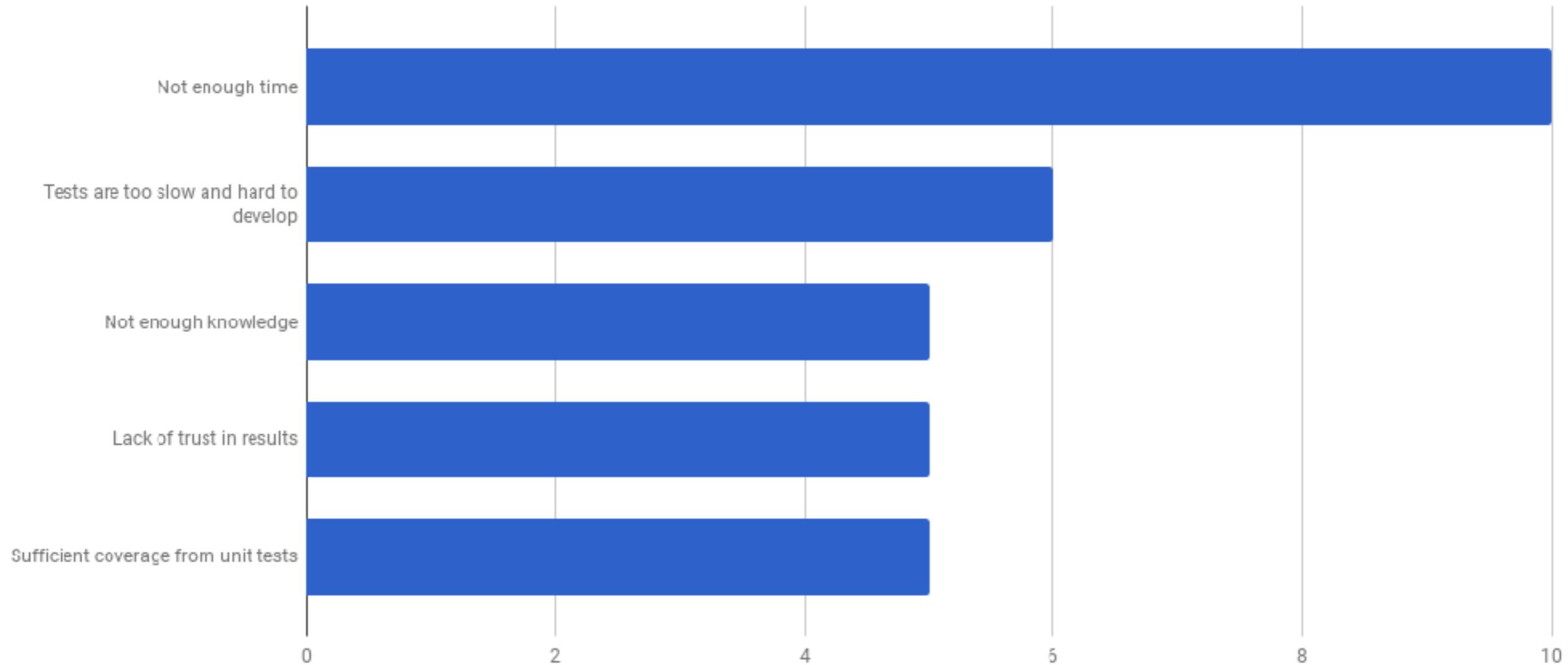
Better documentation



But,
It's take time to learning and
practice !!



Why not write automated tests ?

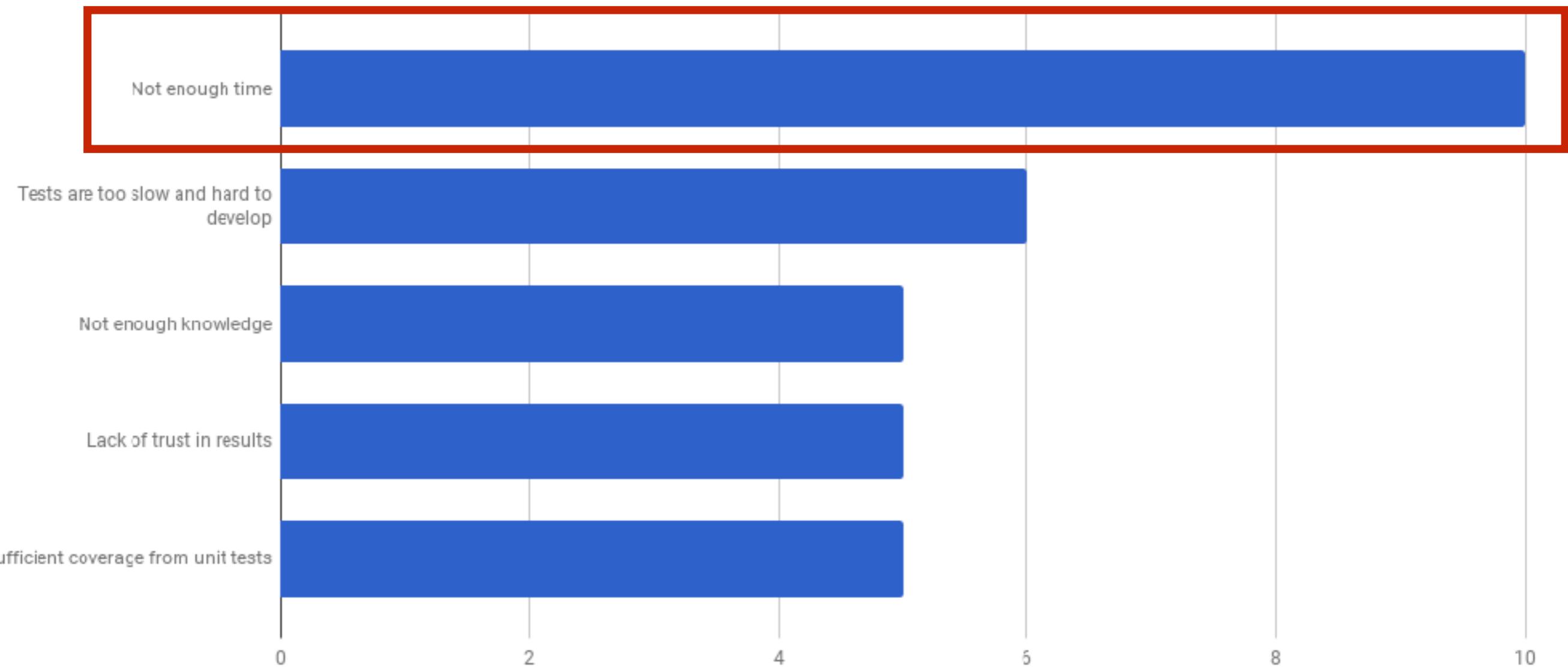


<https://slack.engineering/android-ui-automation-part-1-building-trust-de3deb1c5995>



Why not write automated tests ?

Not enough time !!!



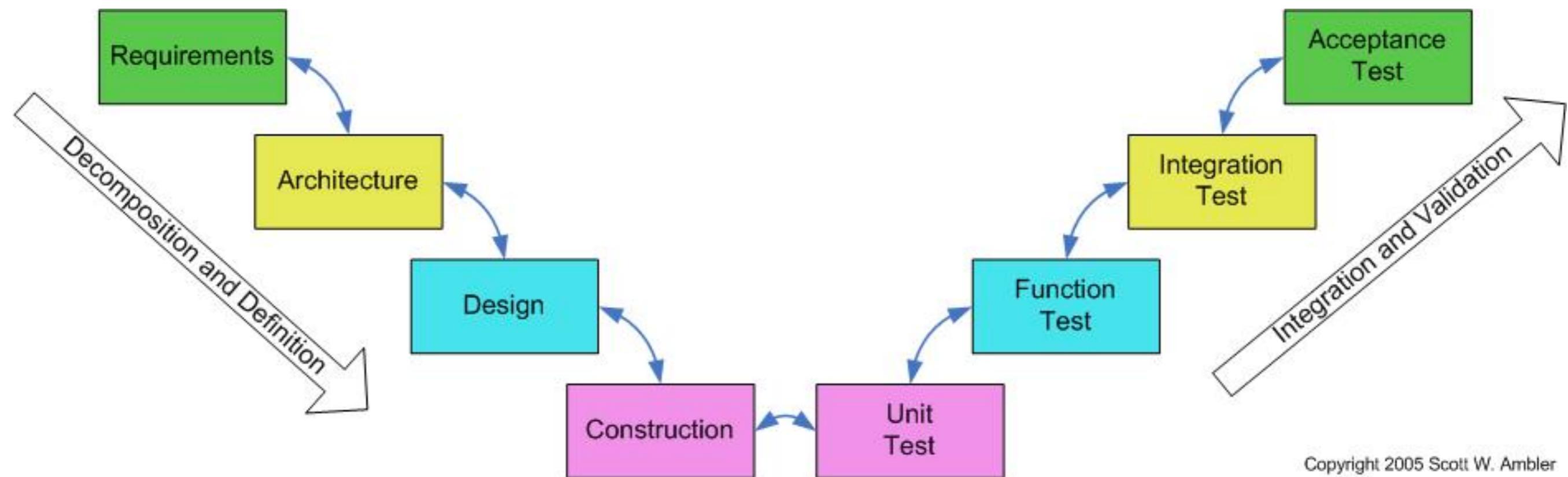
<https://slack.engineering/android-ui-automation-part-1-building-trust-de3deb1c5995>



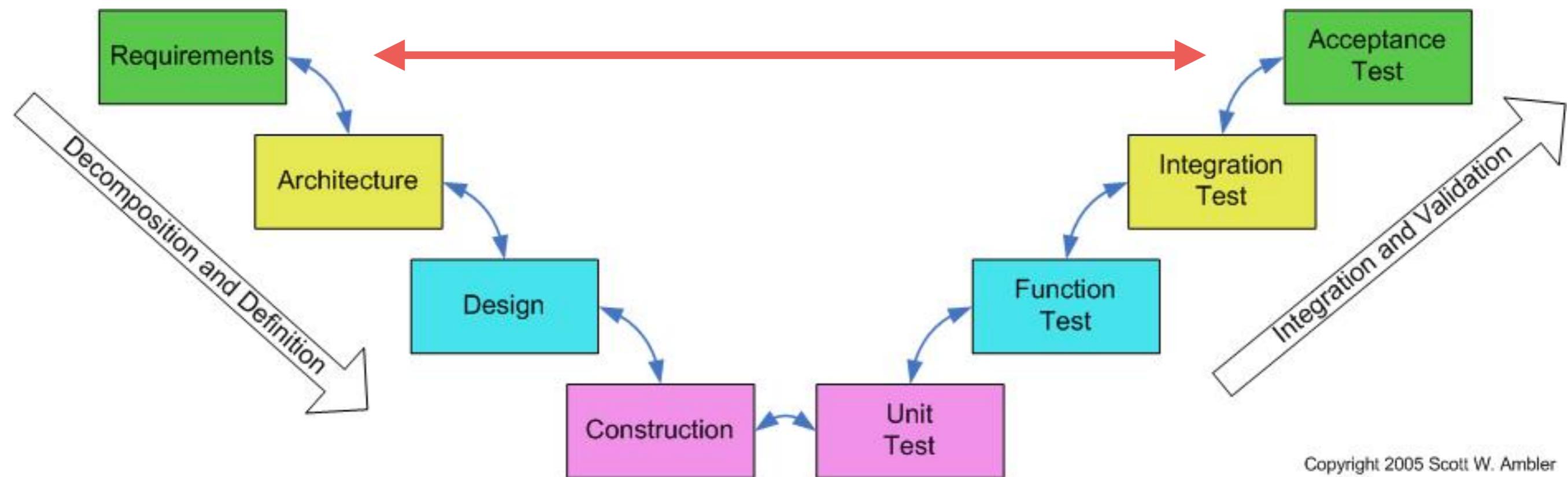
What kind of test should we write ?



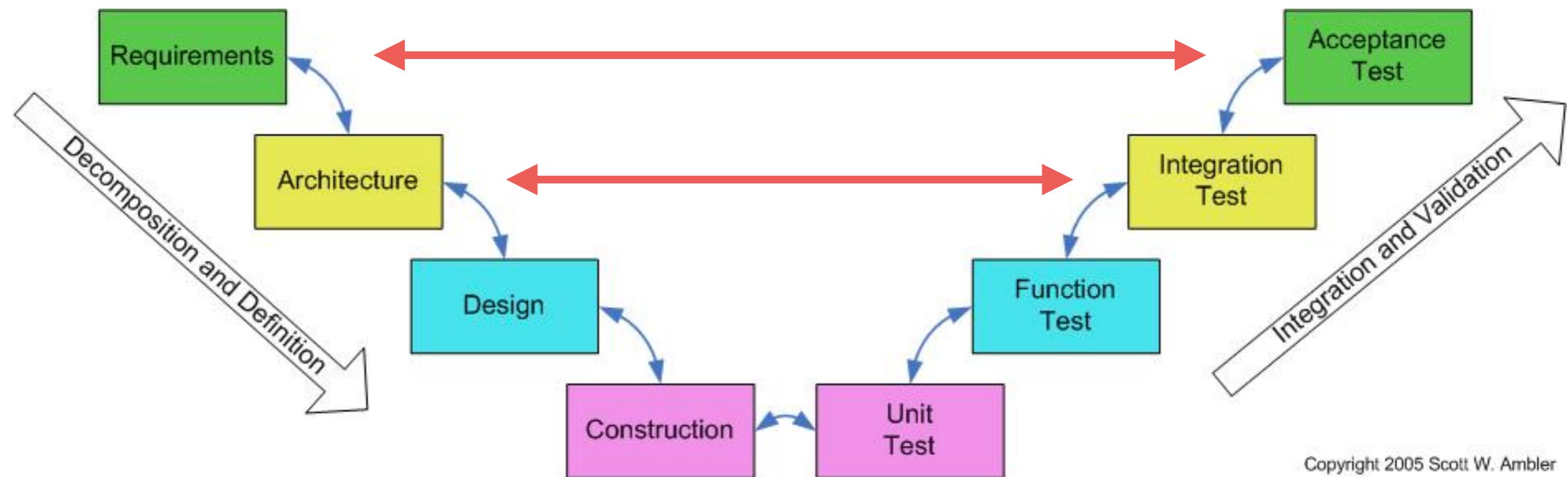
V Model



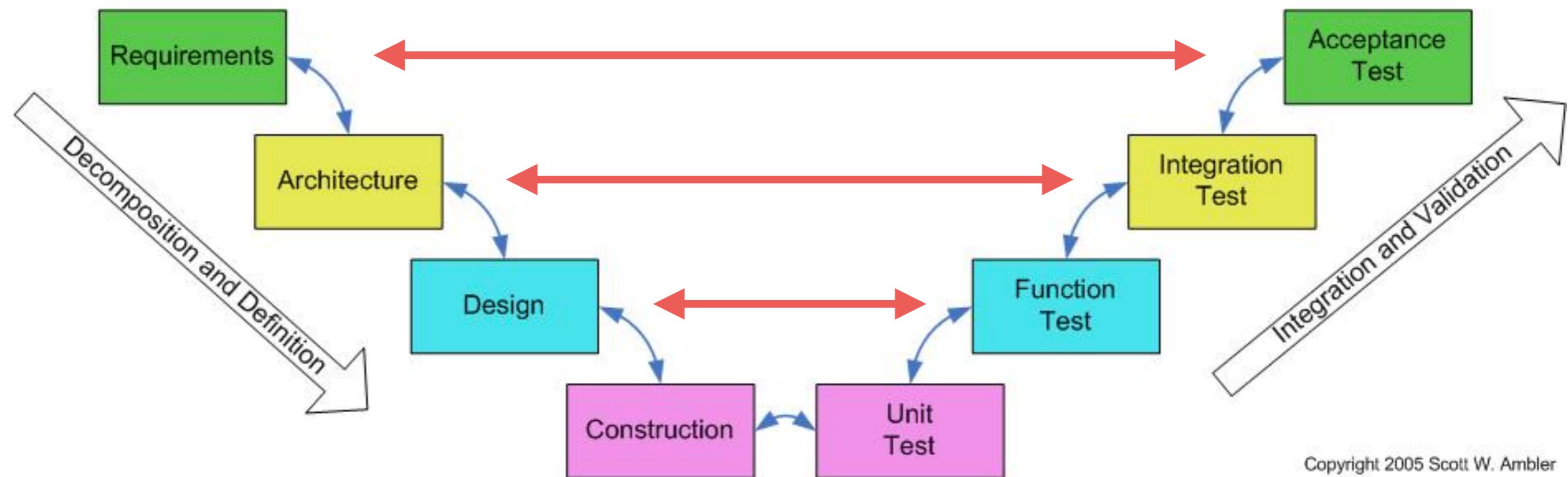
V Model



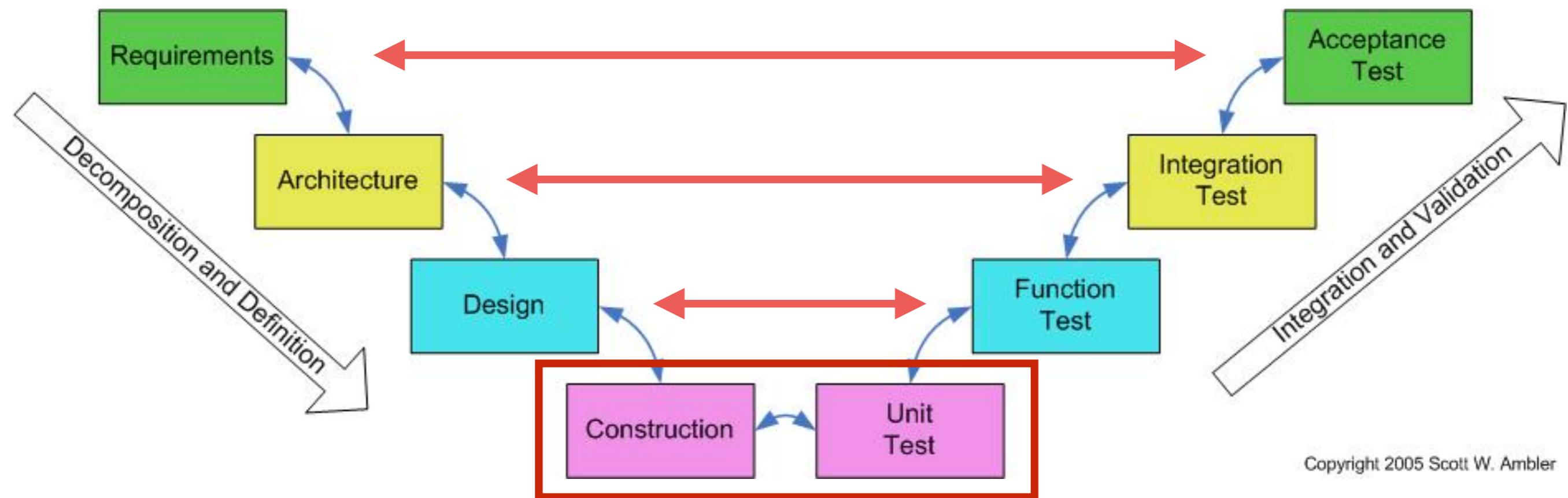
V Model



V Model



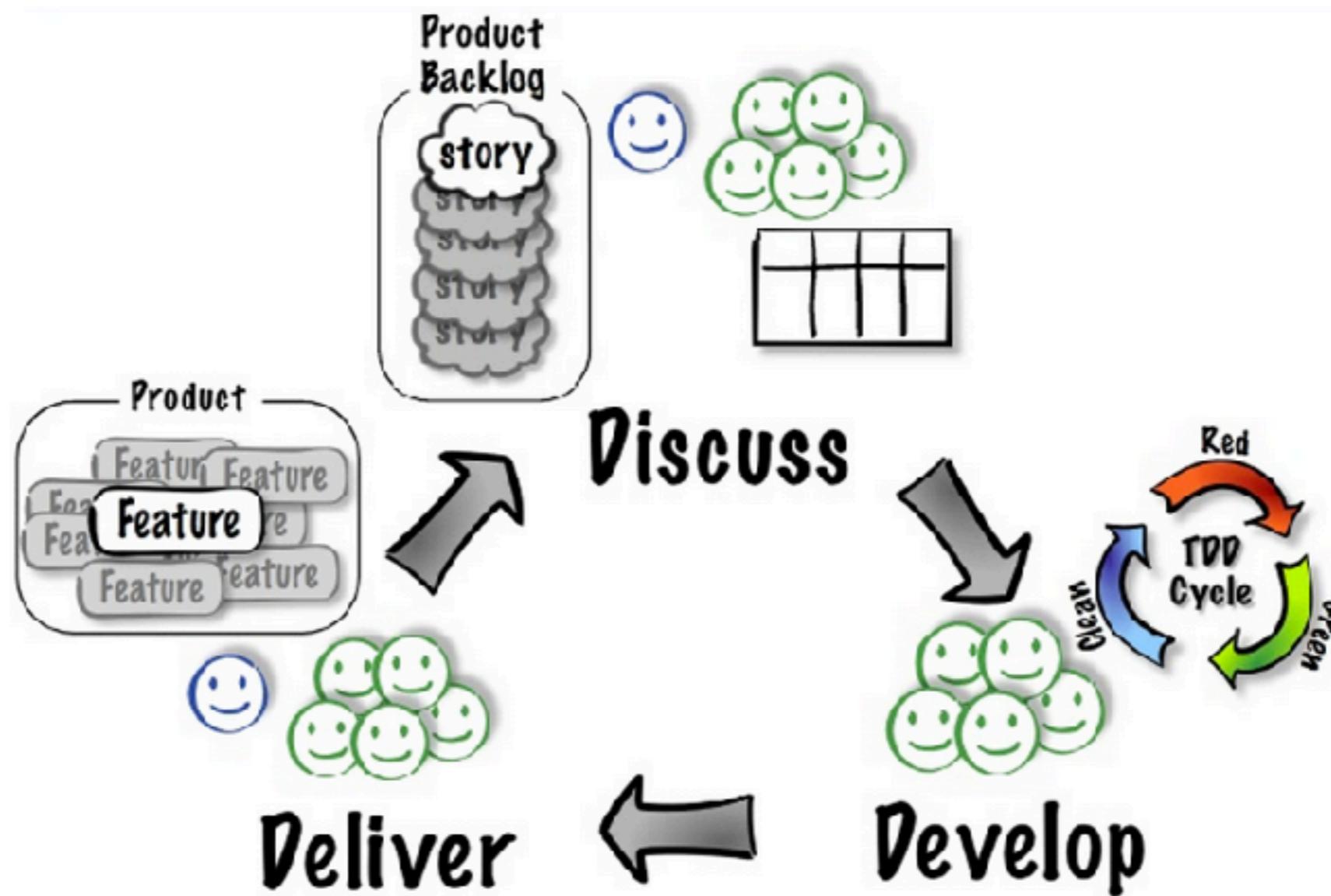
V Model



THINK before coding



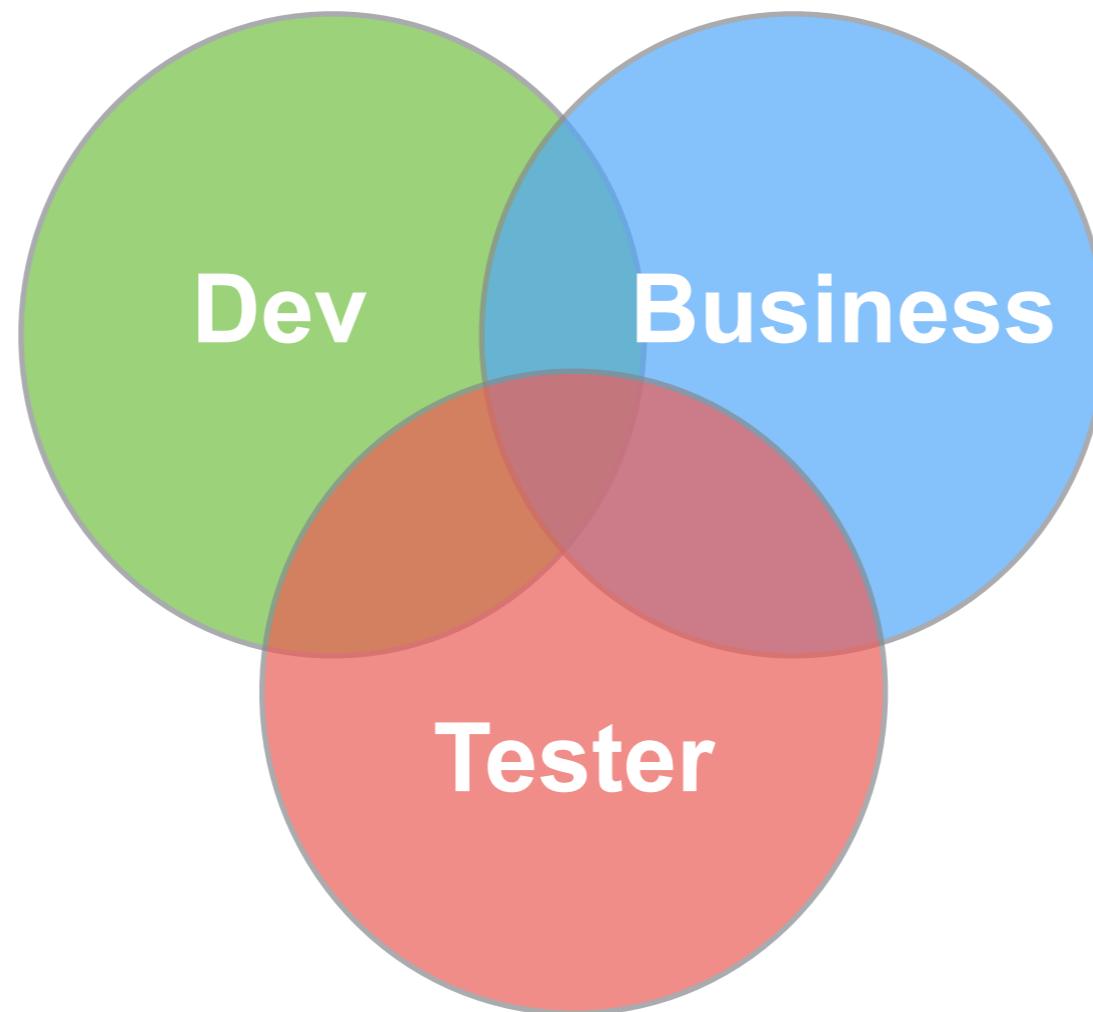
Acceptance Test-Driven Development



(Model developed with Pekka Klärck, Bas Vodde, and Craig Larman.)



Acceptance Test-Driven Development



Acceptance Tests

=

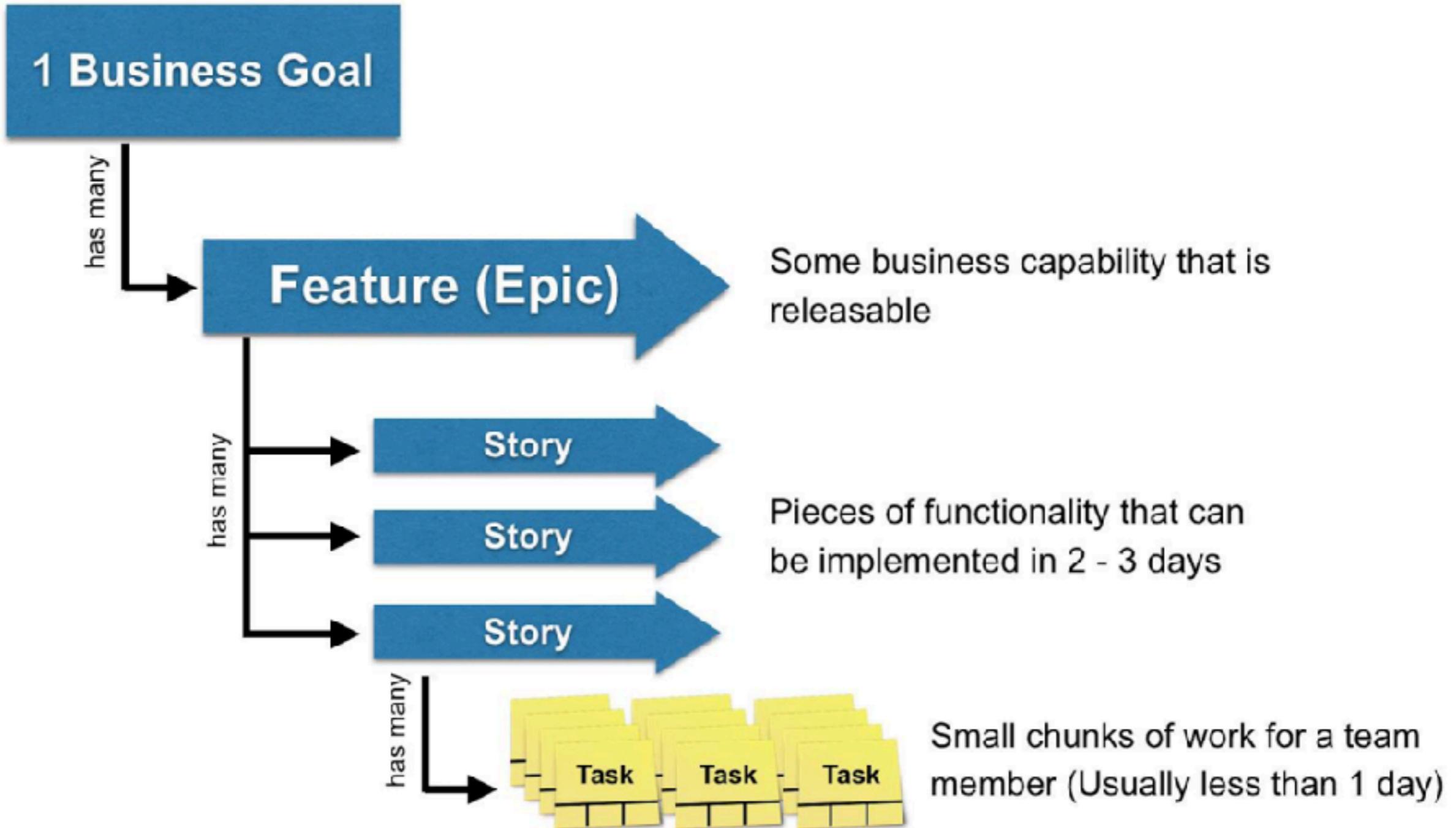
Business Criteria

+

Examples (data)



Work break down



Workshop

Input	Expected result
[1, 5]	1,2,3,4,5
[1, 5)	1,2,3,4
(1, 5]	2,3,4,5
(1, 5)	2,3,4

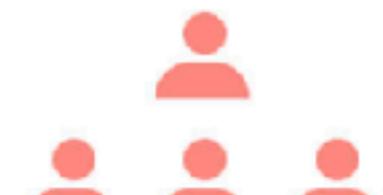
<http://codingdojo.org/kata/Range/>



Whole team approach

Functional

Common functional expertise



System analysts



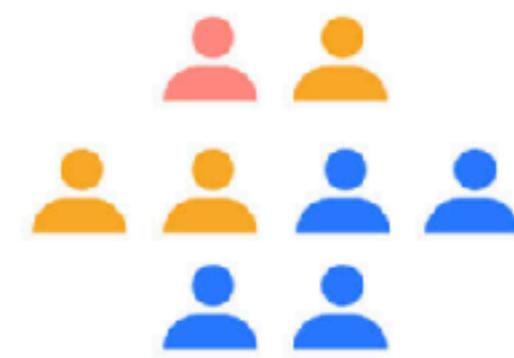
Developers



Testers

Cross - Functional

Representatives from the various functions



Development Team



Key success factors

Whole team solve problems

Whole team thinks about testing

Whole team **committed to quality**

Everyone collaborates



Iterative and incremental process

Feature 1

Time



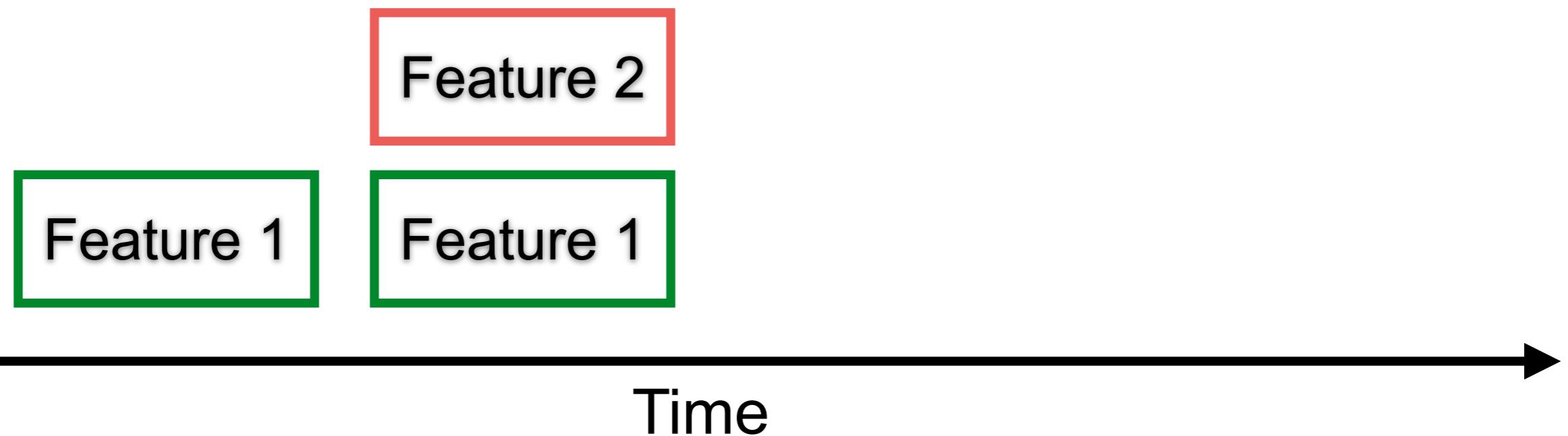
Iterative and incremental process

Done = coded and tested



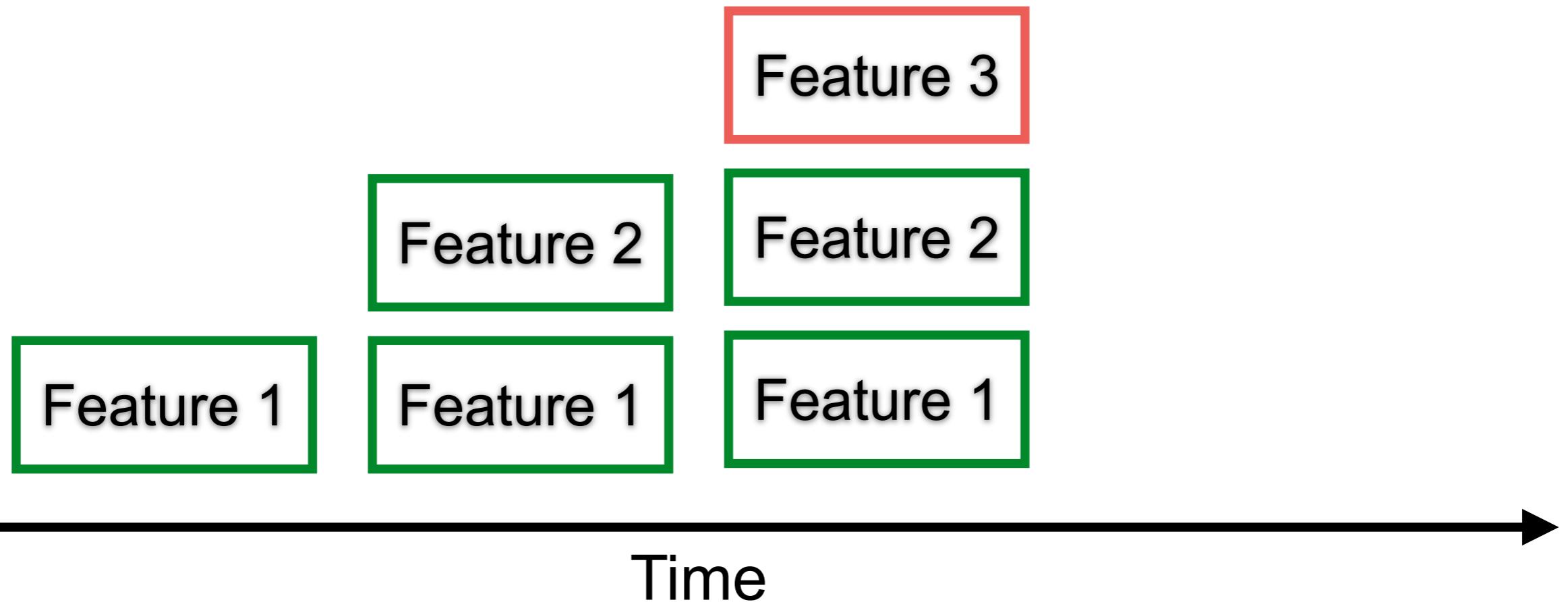
Iterative and incremental process

Done = coded and tested



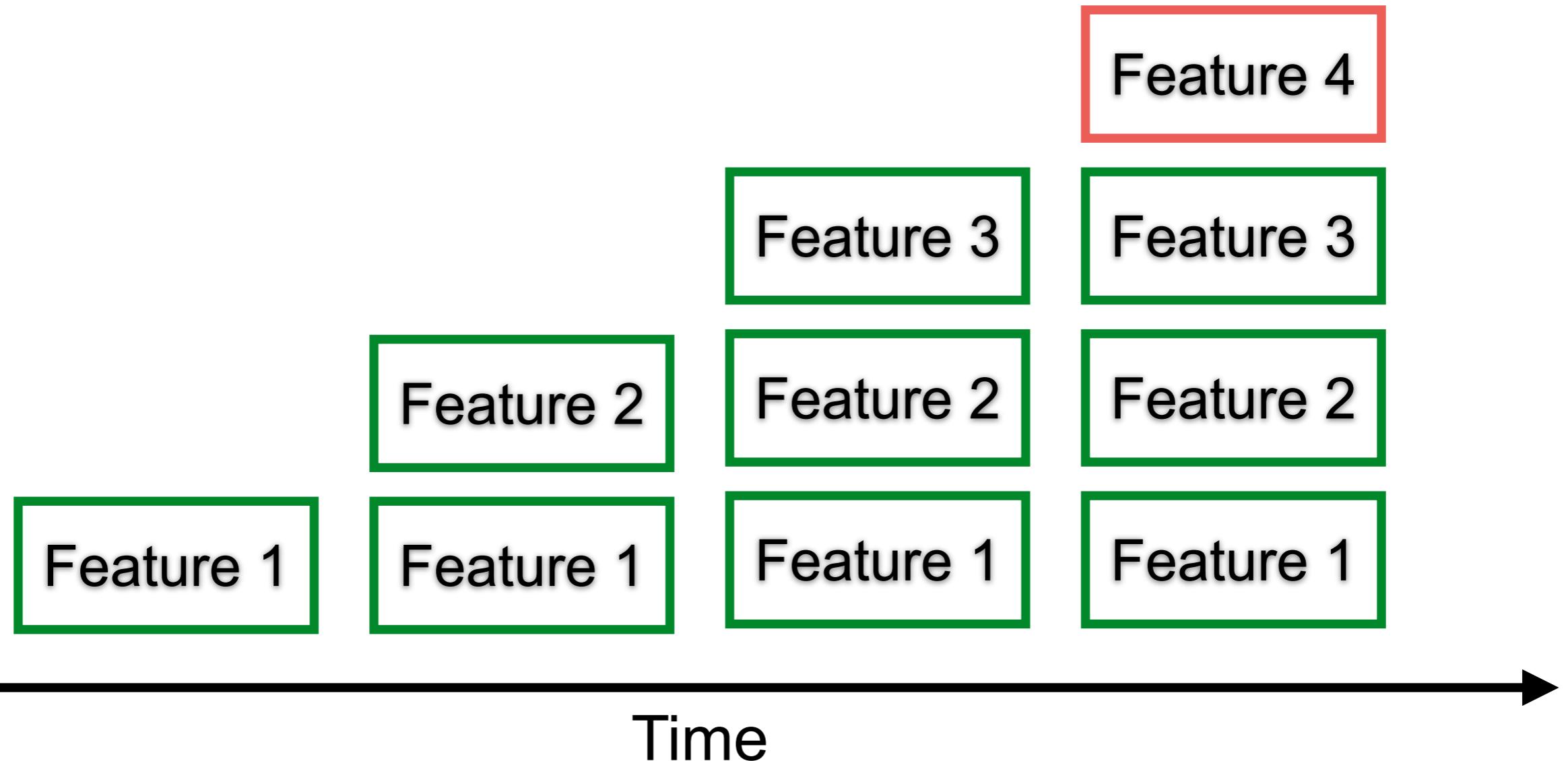
Iterative and incremental process

Done = coded and tested



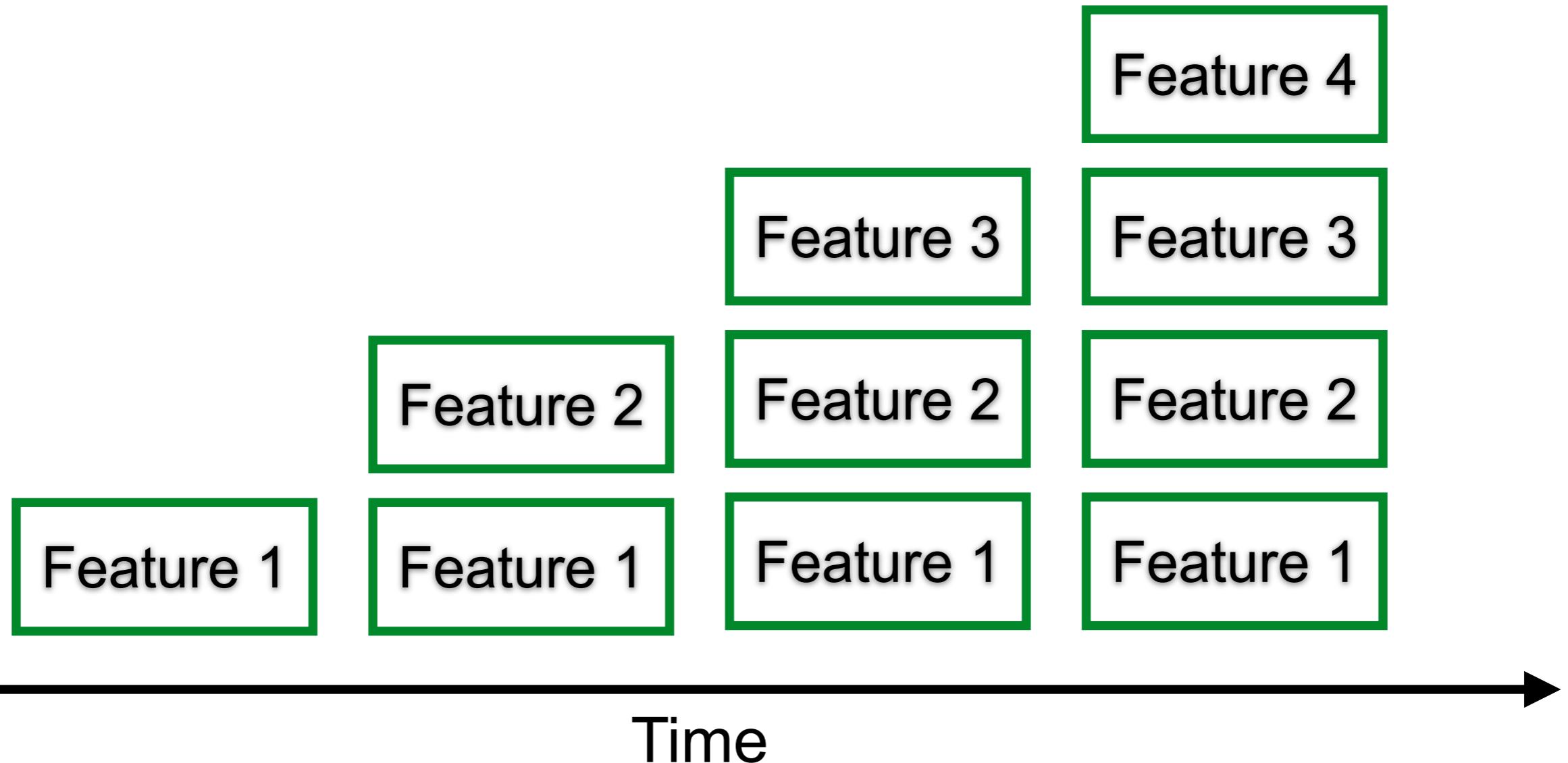
Iterative and incremental process

Done = coded and tested



Iterative and incremental process

Done = coded and tested



Testing is activity

~~Test phase~~

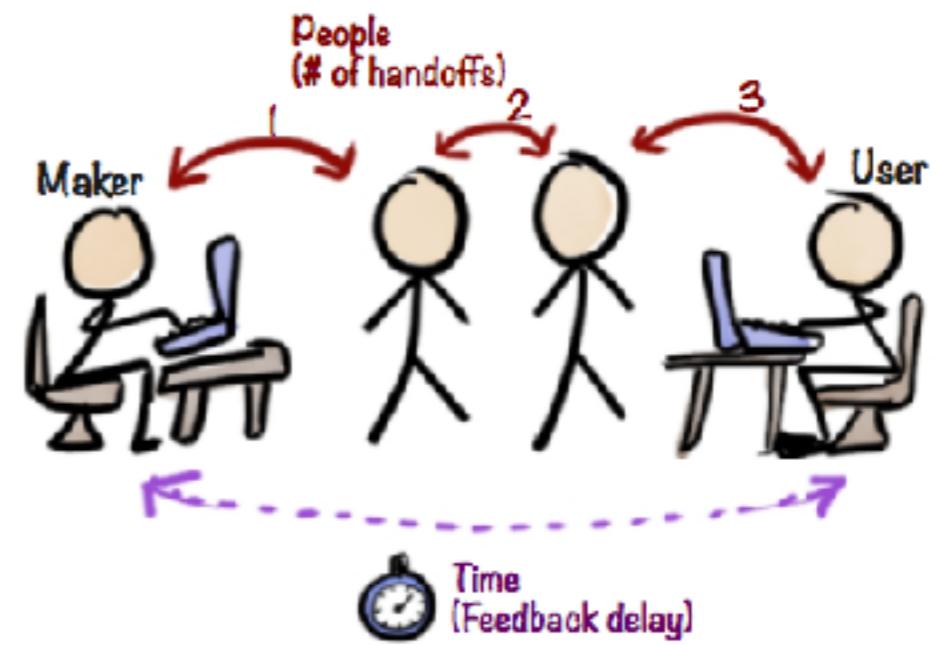
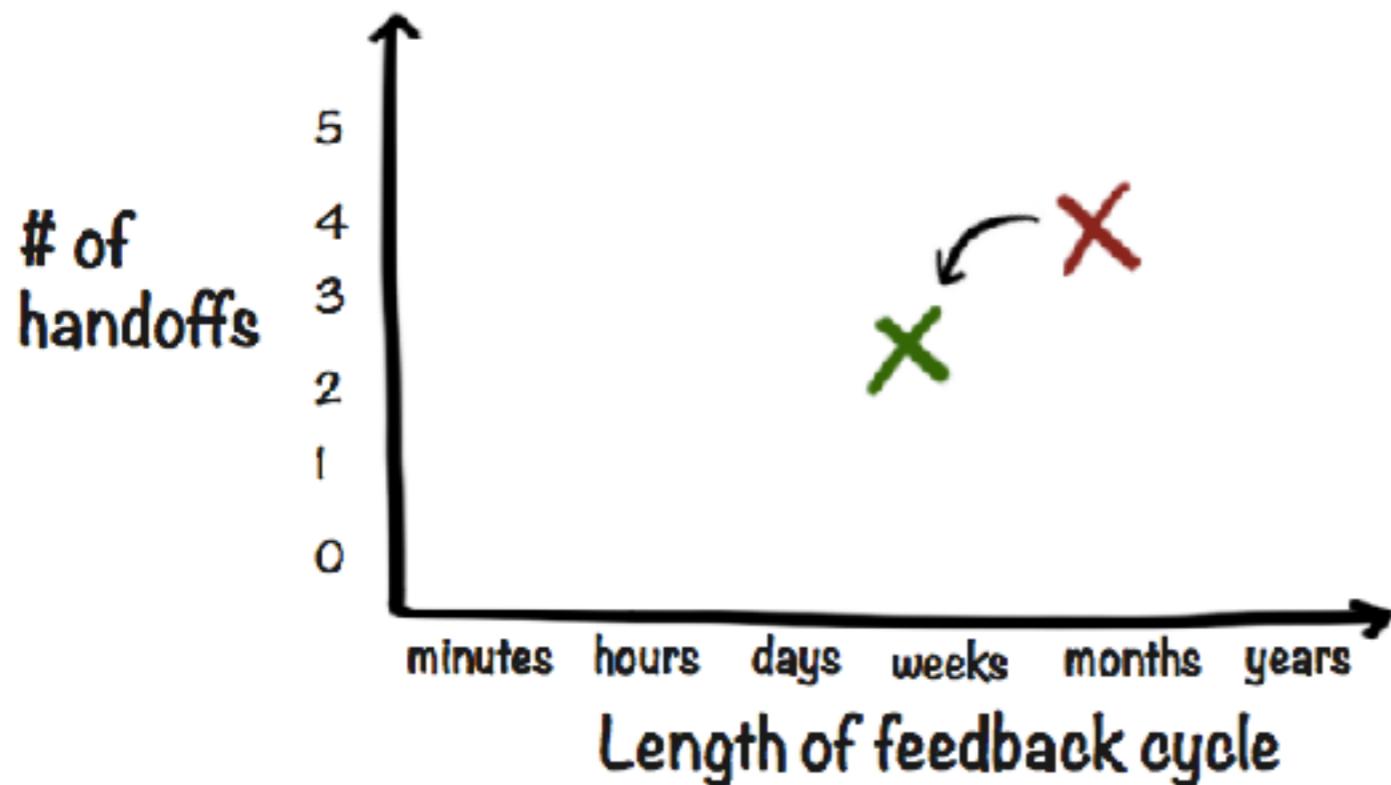
~~Test team~~

~~Tester role~~

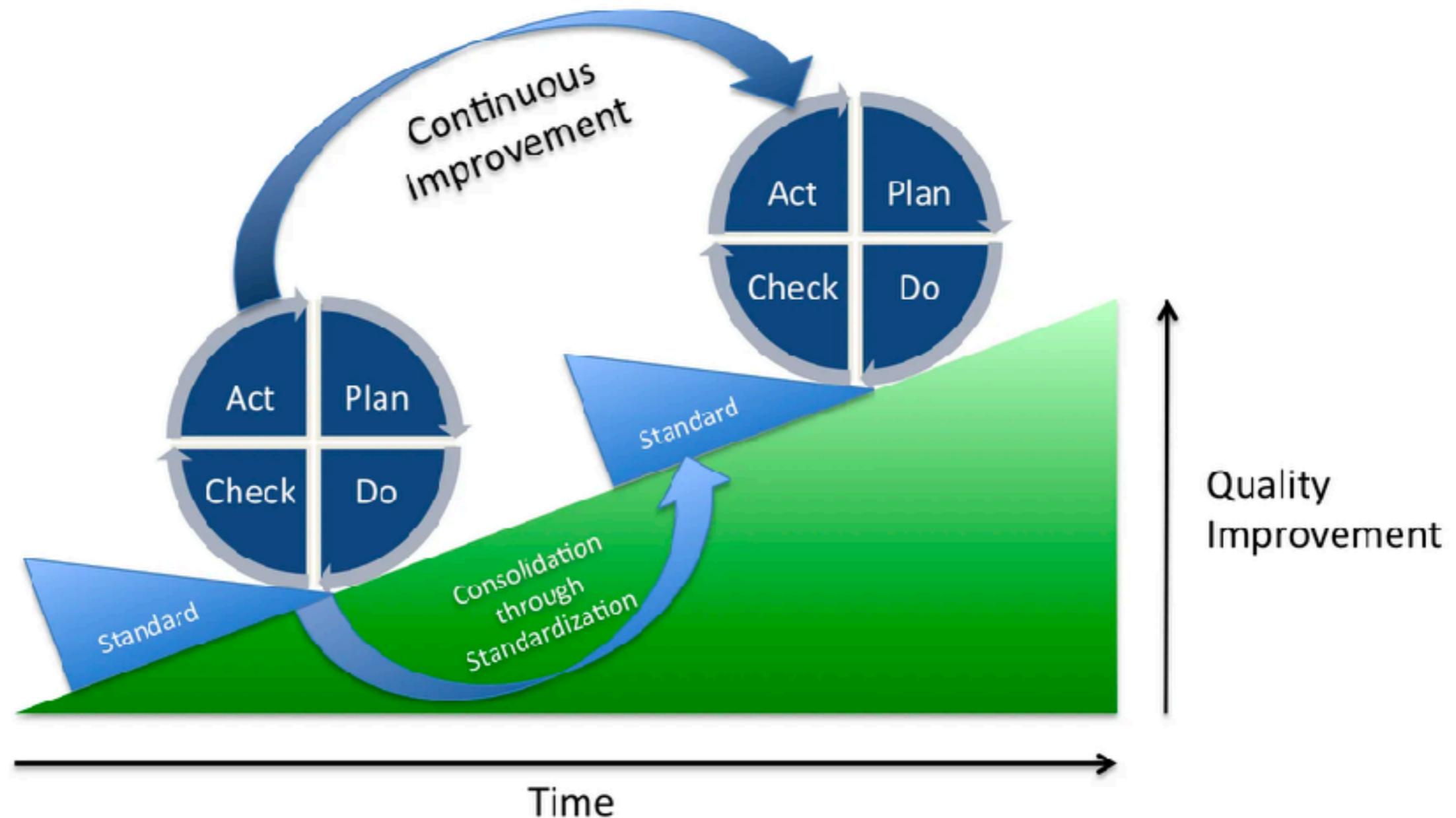


Fast feedback loop

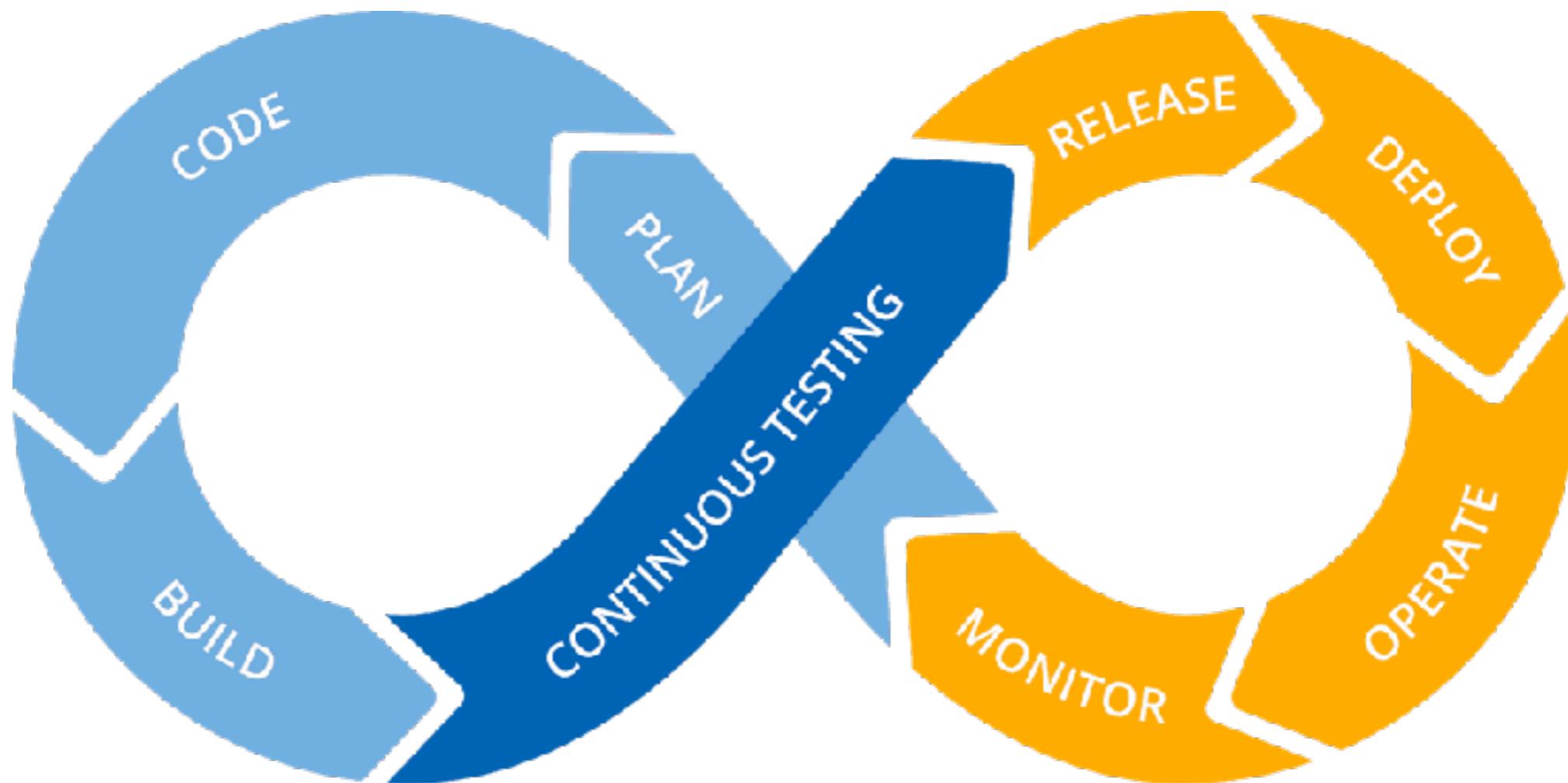
Shorten the feedback loop



Continuous improvement



Continuous testing



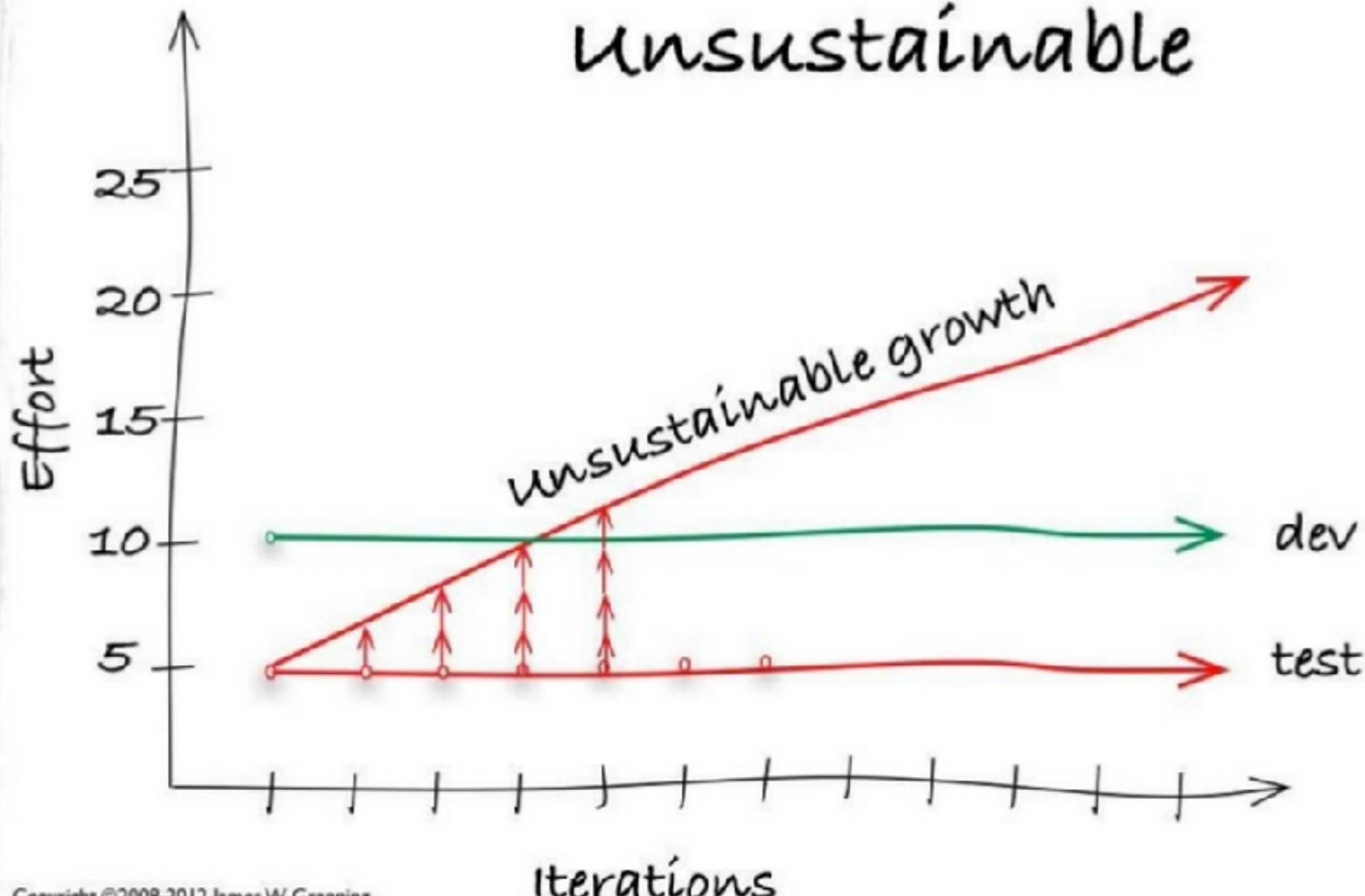
But ...



Manual testing ?



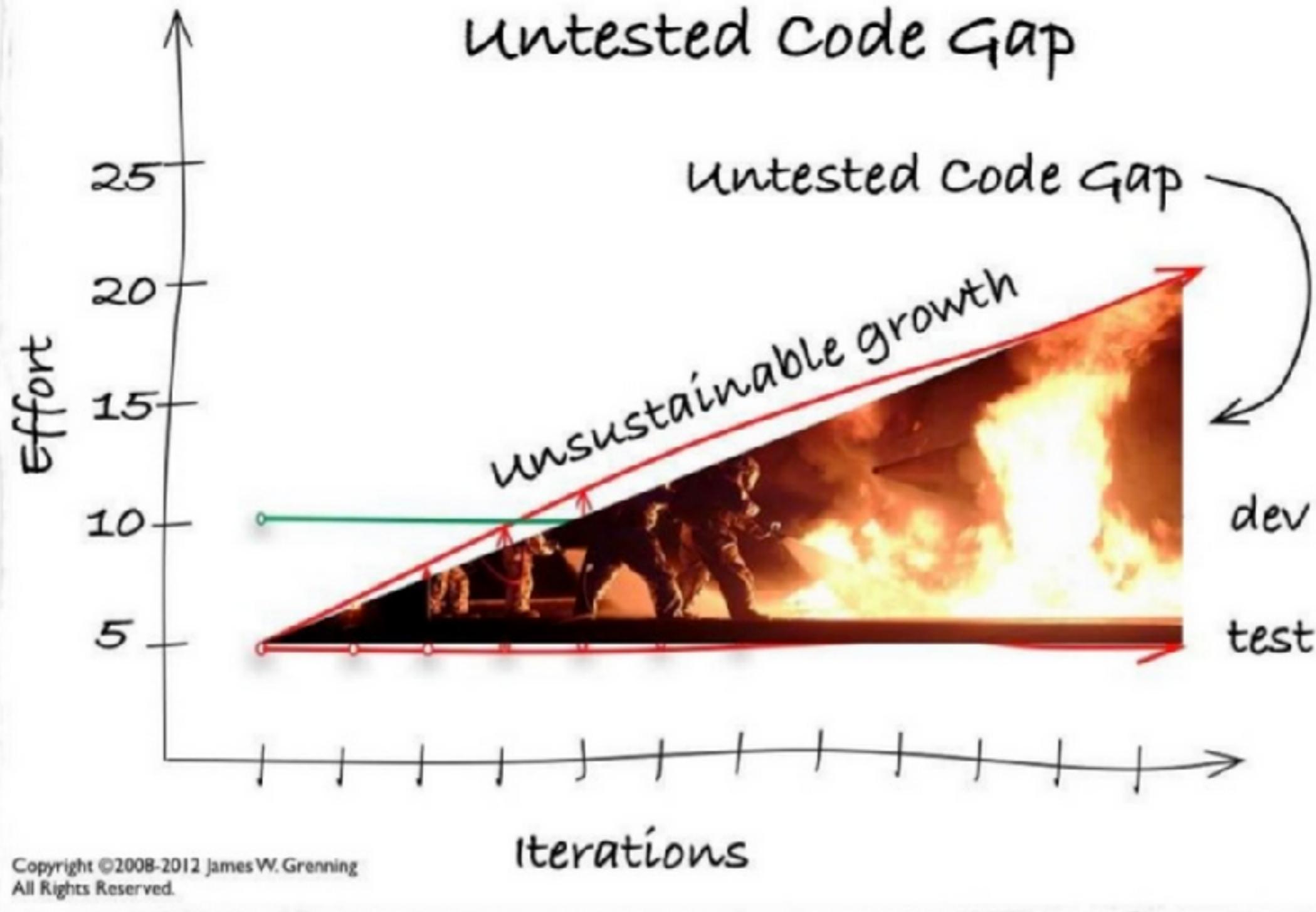
Manual Test is unsustainable



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Risk Accumulates in the Untested Code Gap



We need automation !!



Why should you automate ?

Manual checking take too long

Manual checks are error prone

Free people to do their best work

Provides living document

Repeatable

Save time



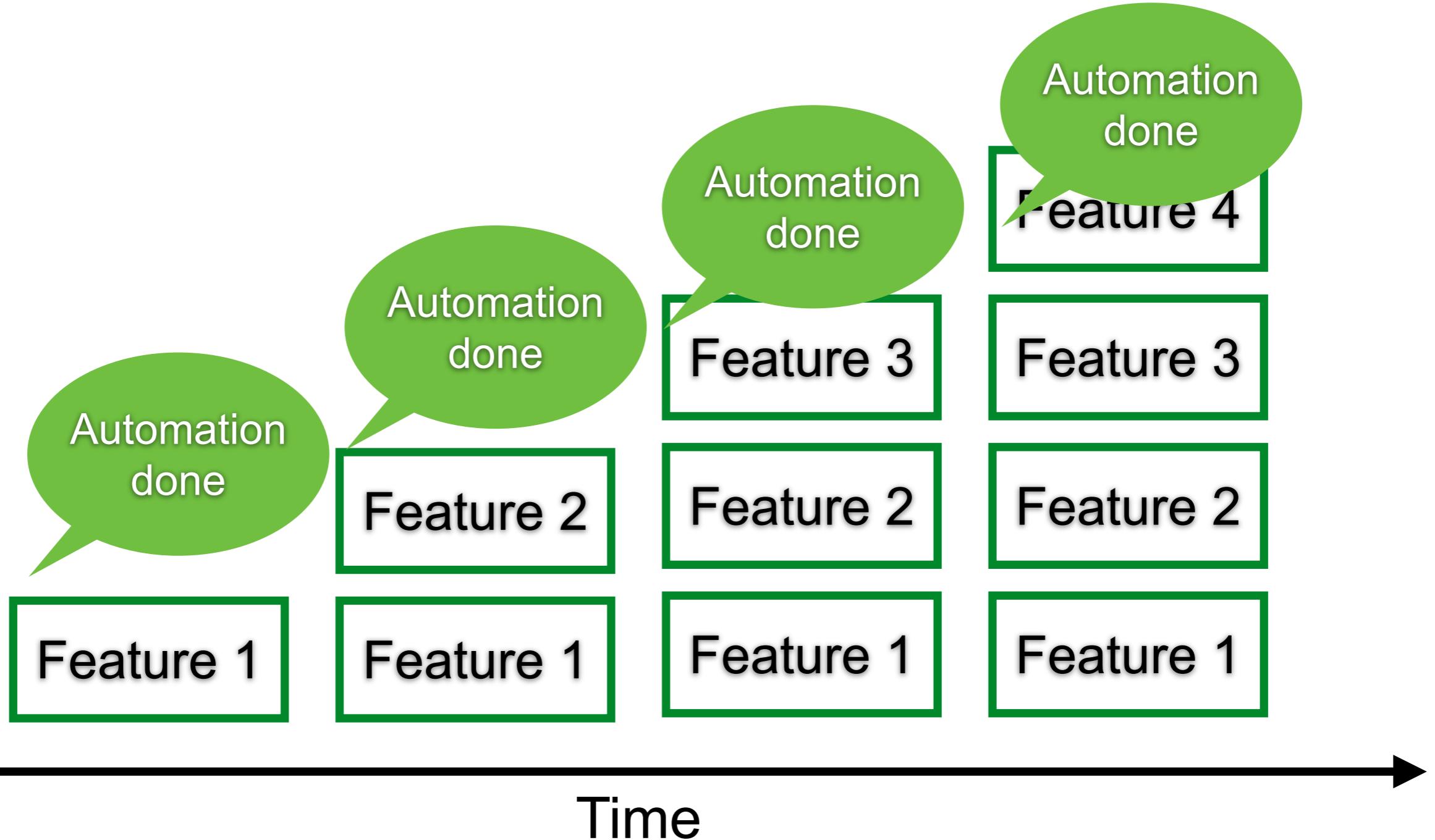
Workshop

Why aren't you automate ?
Share obstacles in your group



Iterative and incremental process

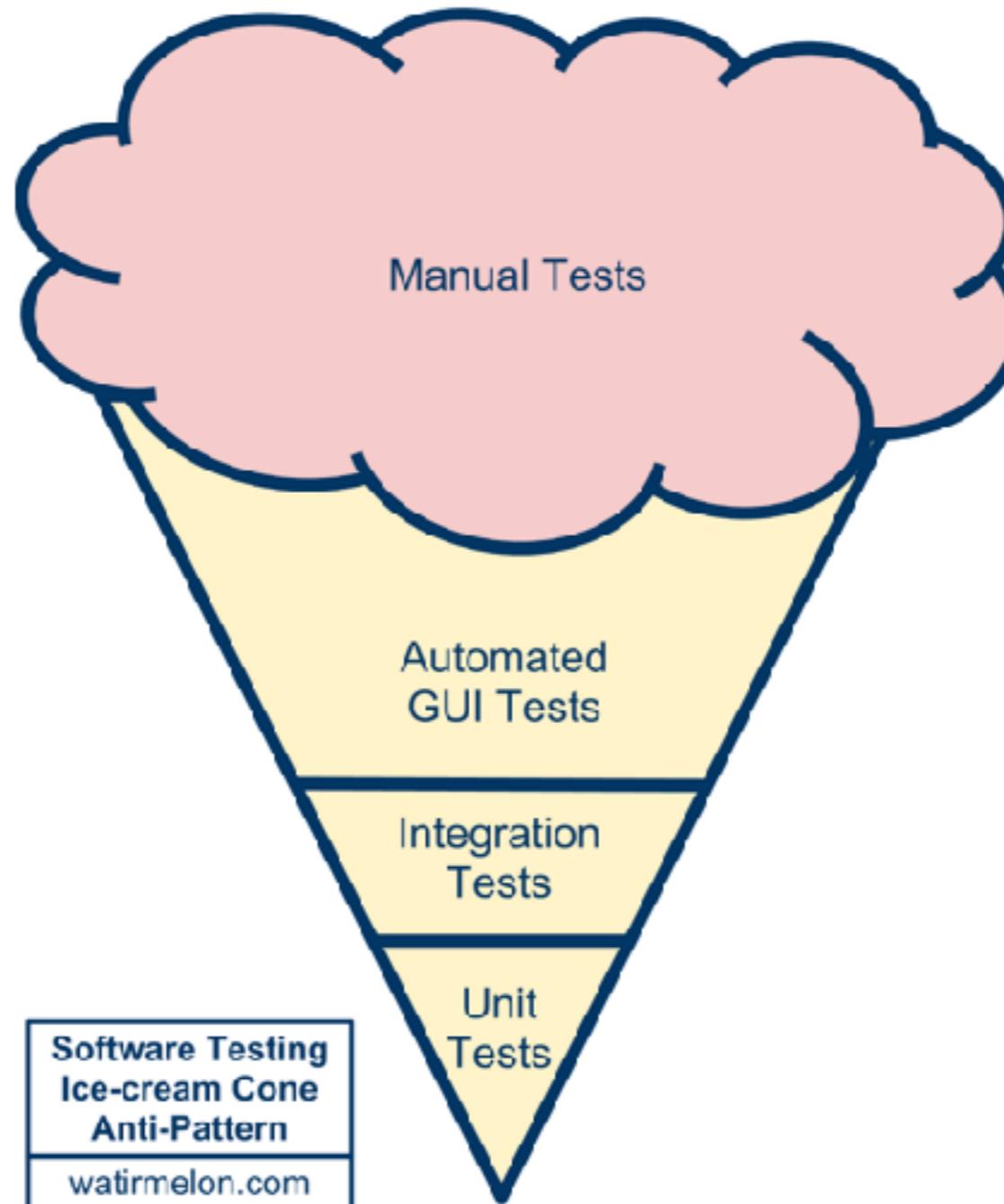
Done = coded and tested



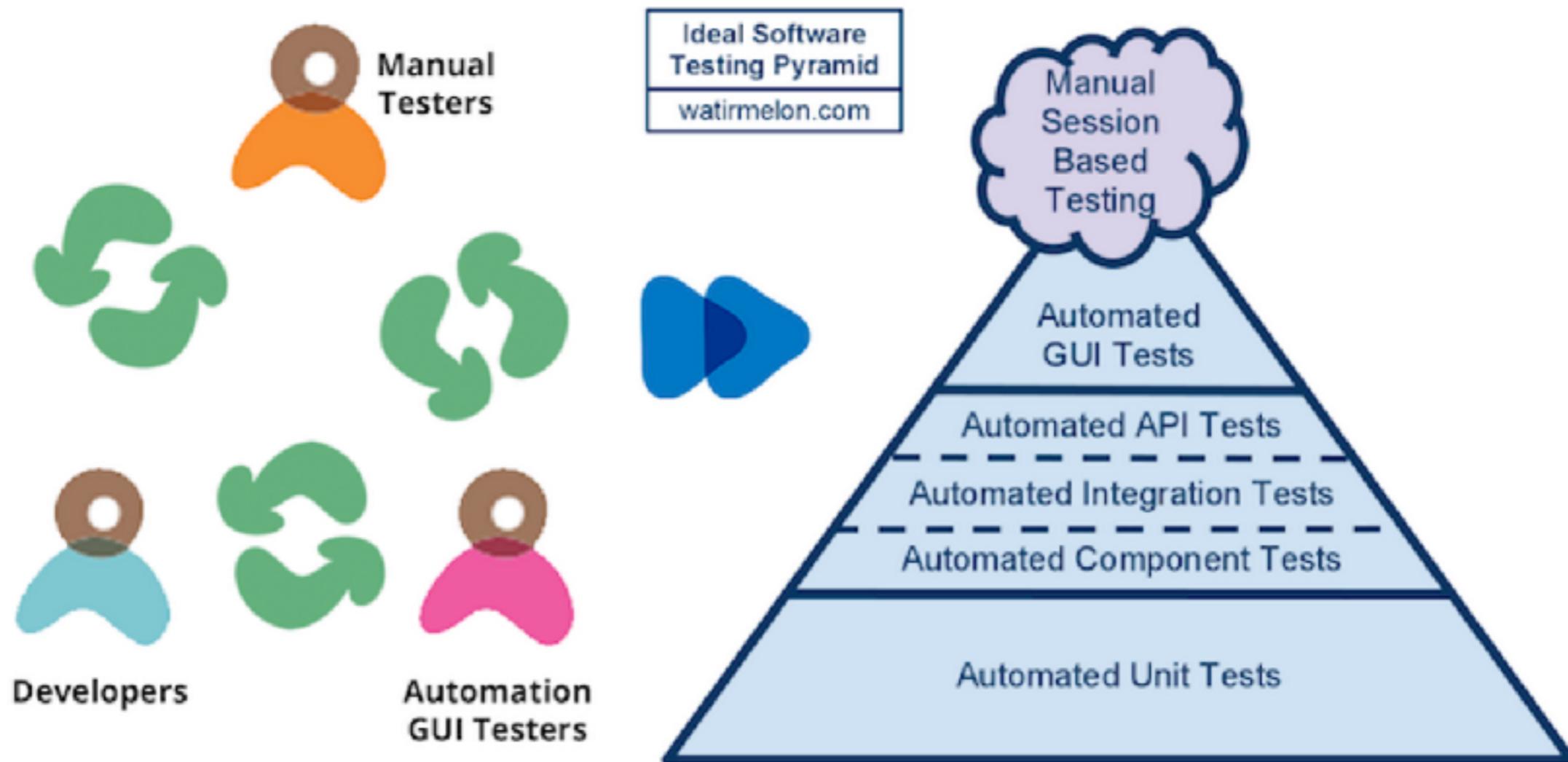
Testing pyramid



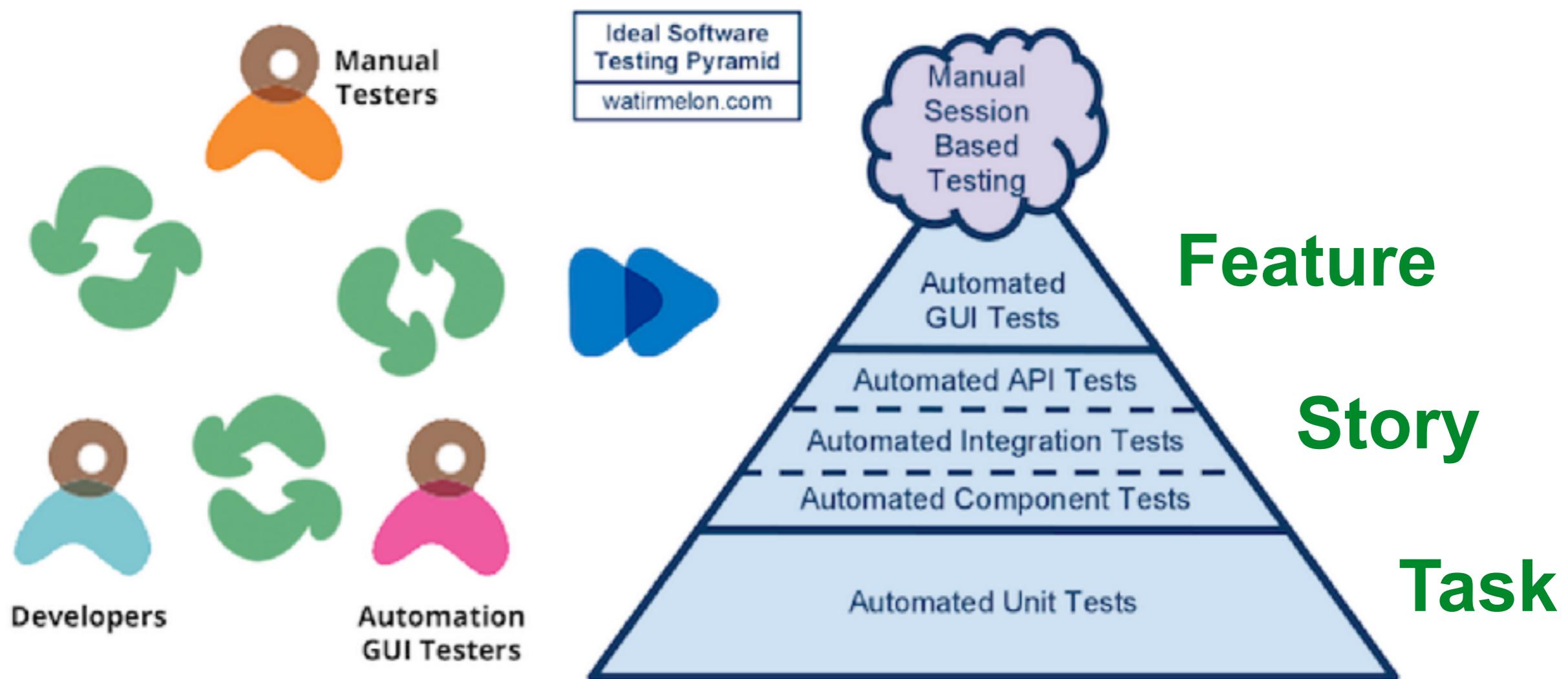
Ice-cream testing



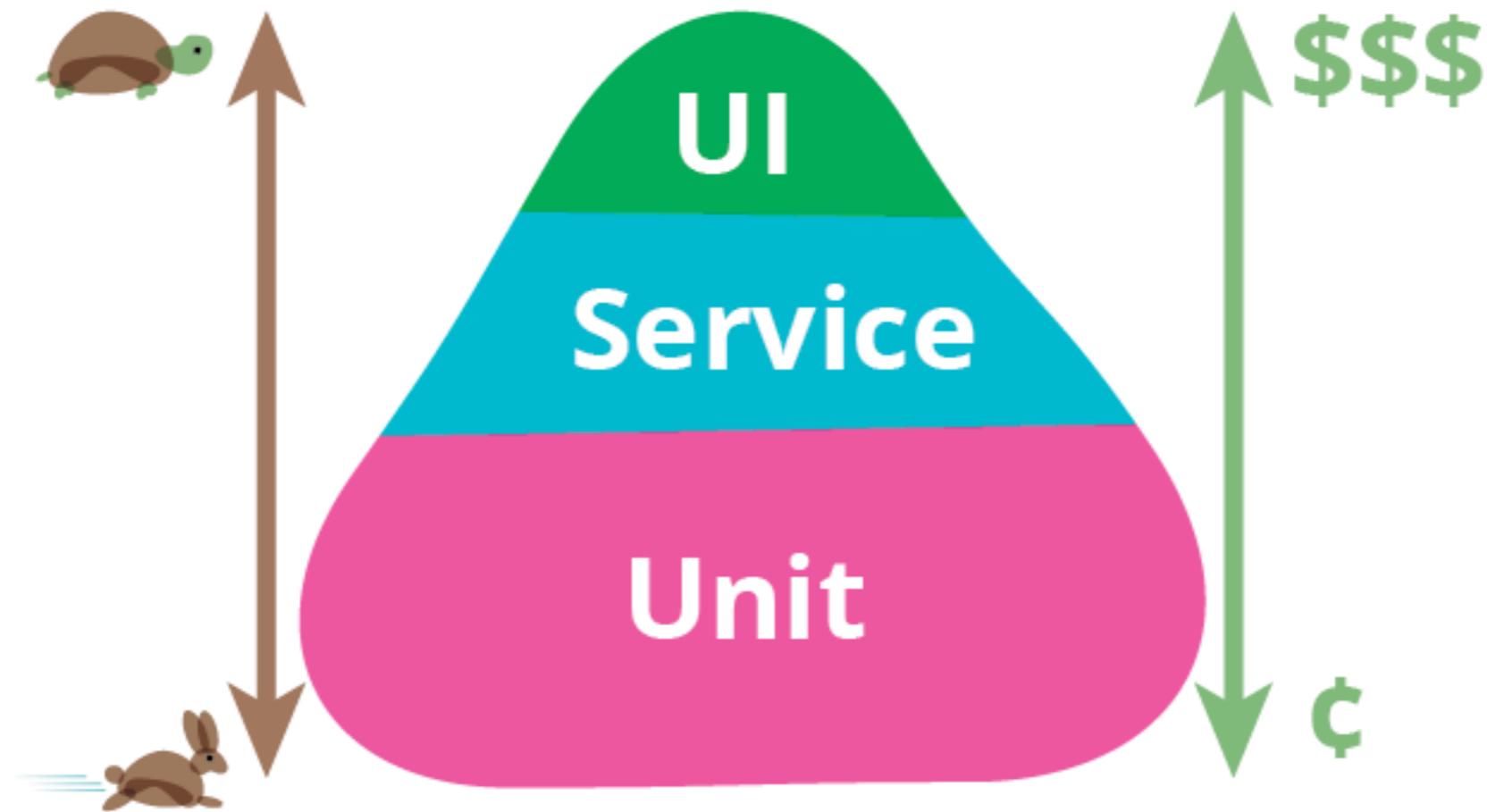
Testing Pyramid



Testing Pyramid

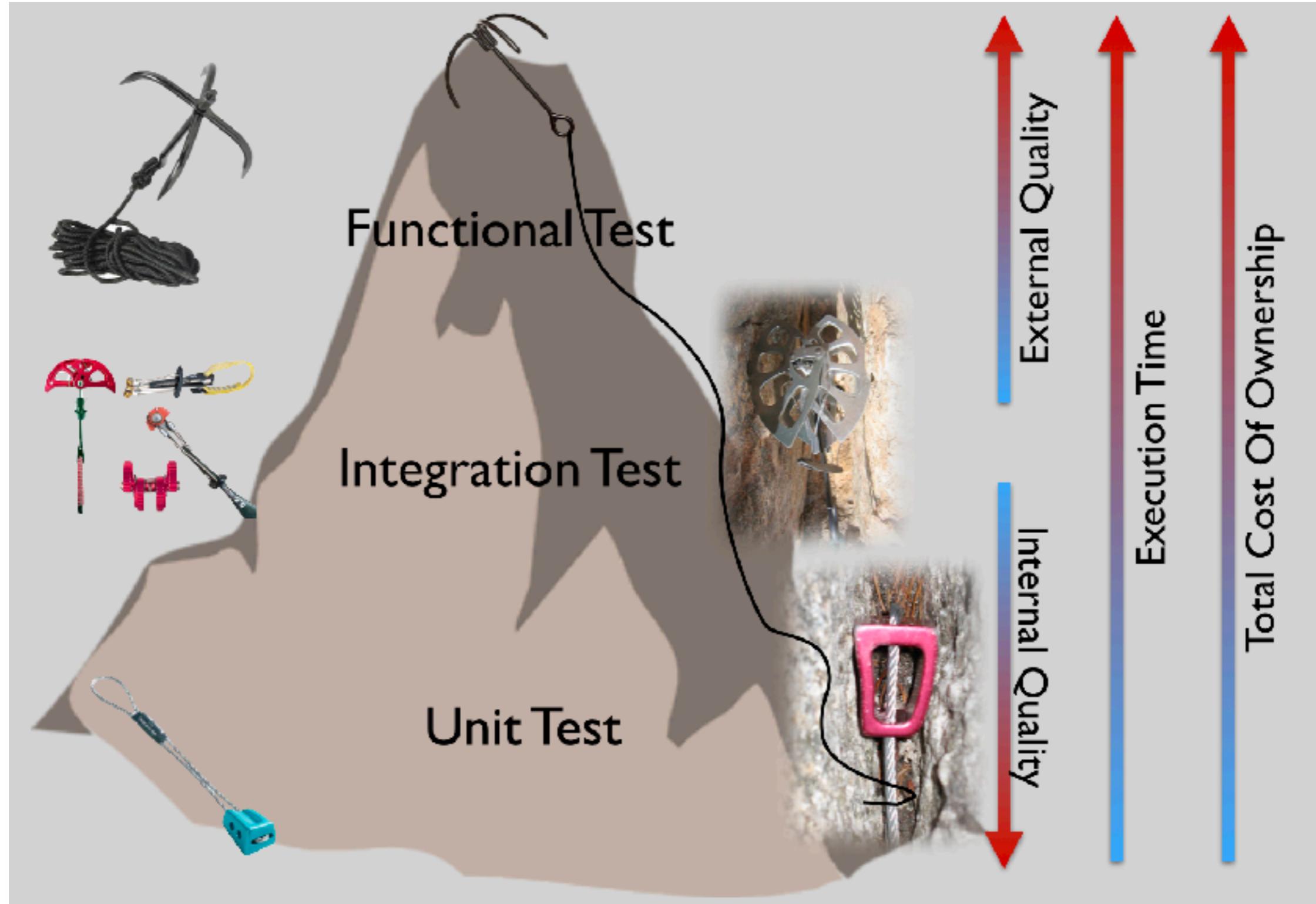


Testing Pyramid



<https://martinfowler.com/bliki/TestPyramid.html>

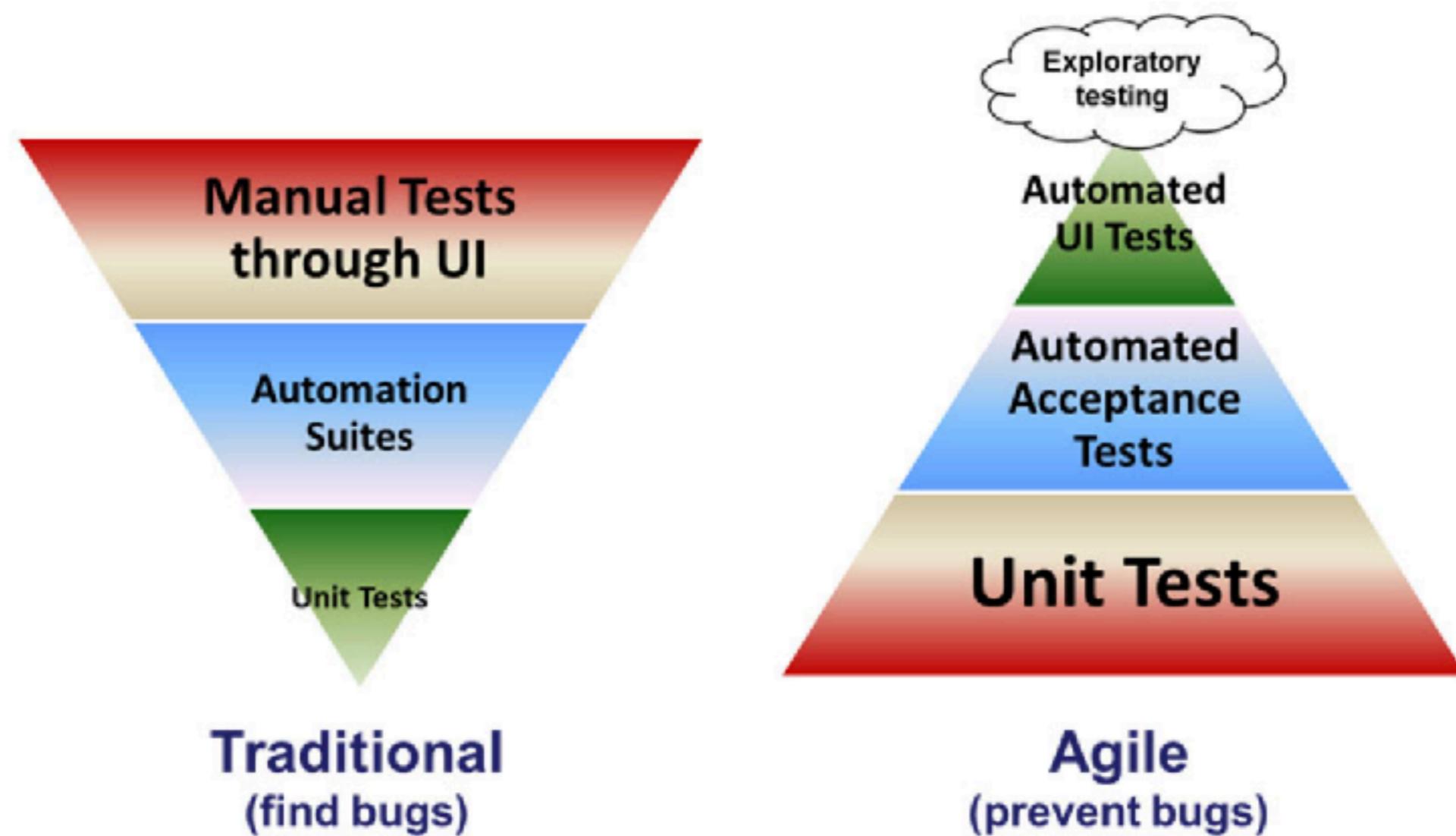




<https://less.works/less/technical-excellence/unit-testing.html>



Find vs Prevent



<https://martinfowler.com/bliki/TestPyramid.html>



Mind-set switch

Instead of

We are here to **find bug**

We are here to **ensure requirement are met**

We are here to **break the software**



Mind-set switch

Instead of

We are here to **find bug**

We are here to **ensure requirement are met**

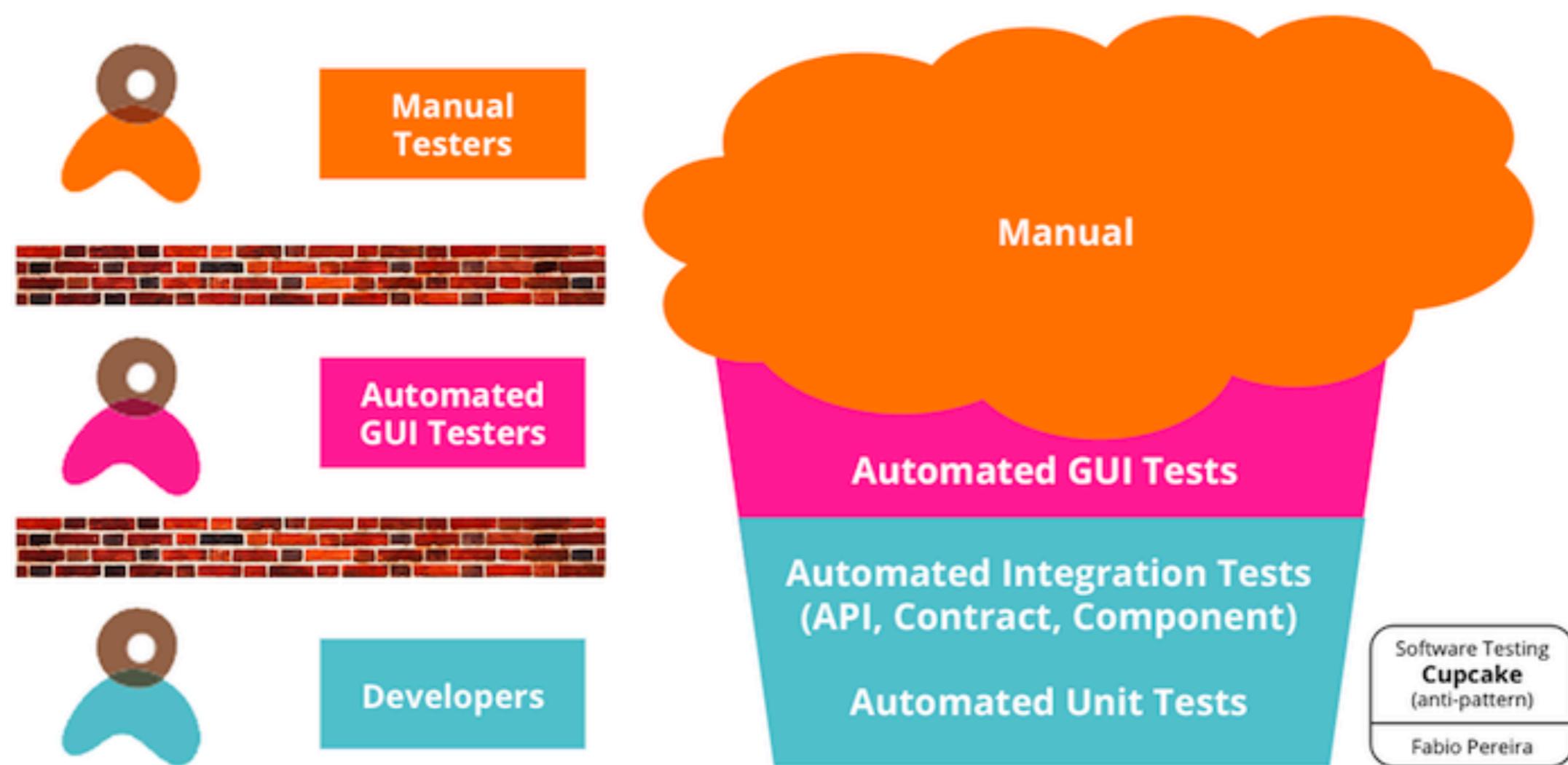
We are here to **break the software**

Think

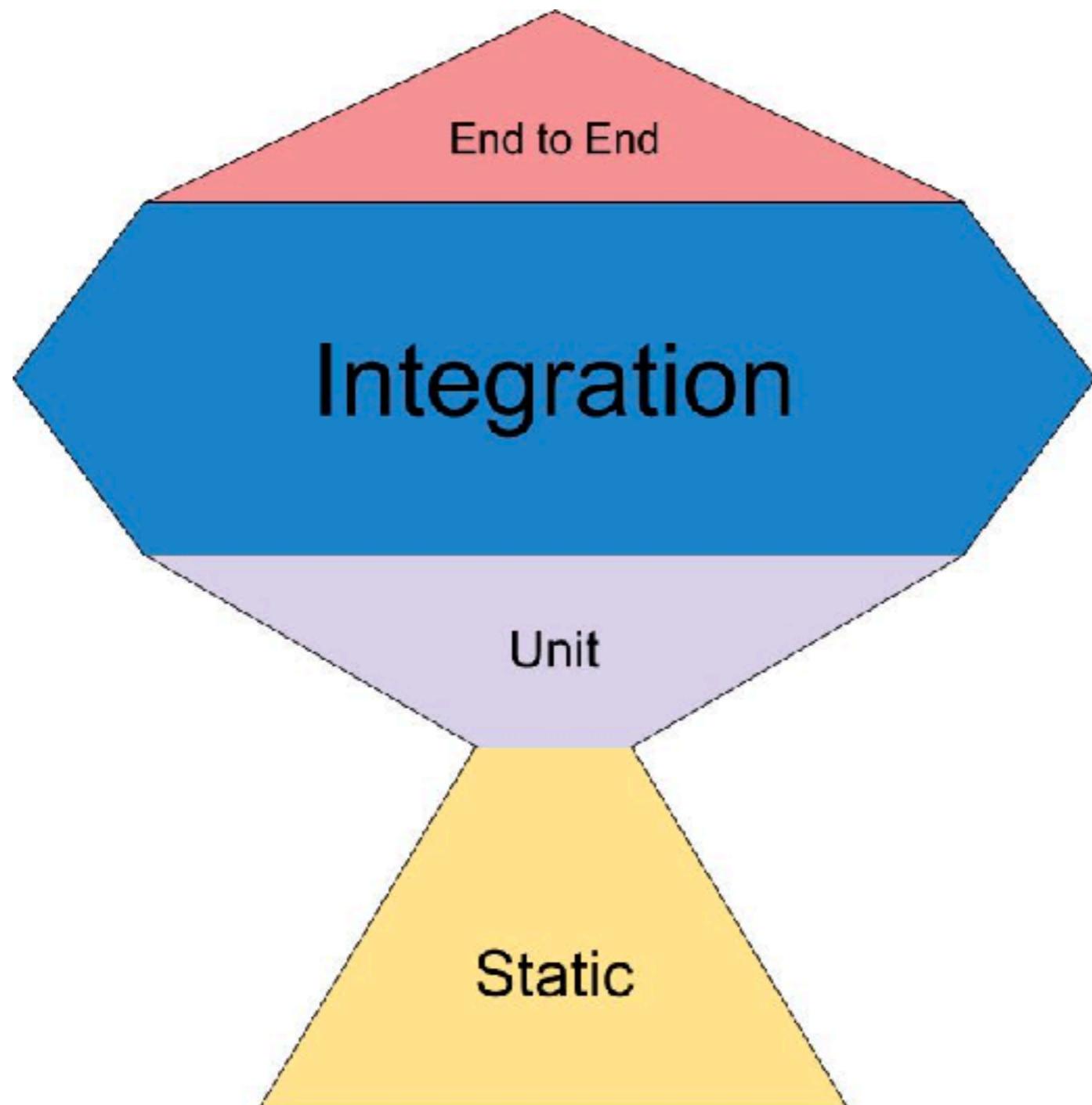
What can I do to help deliver the software
successfully !!



Cupcake testing



Trophy testing



Workshop Test Pyramid



Test login

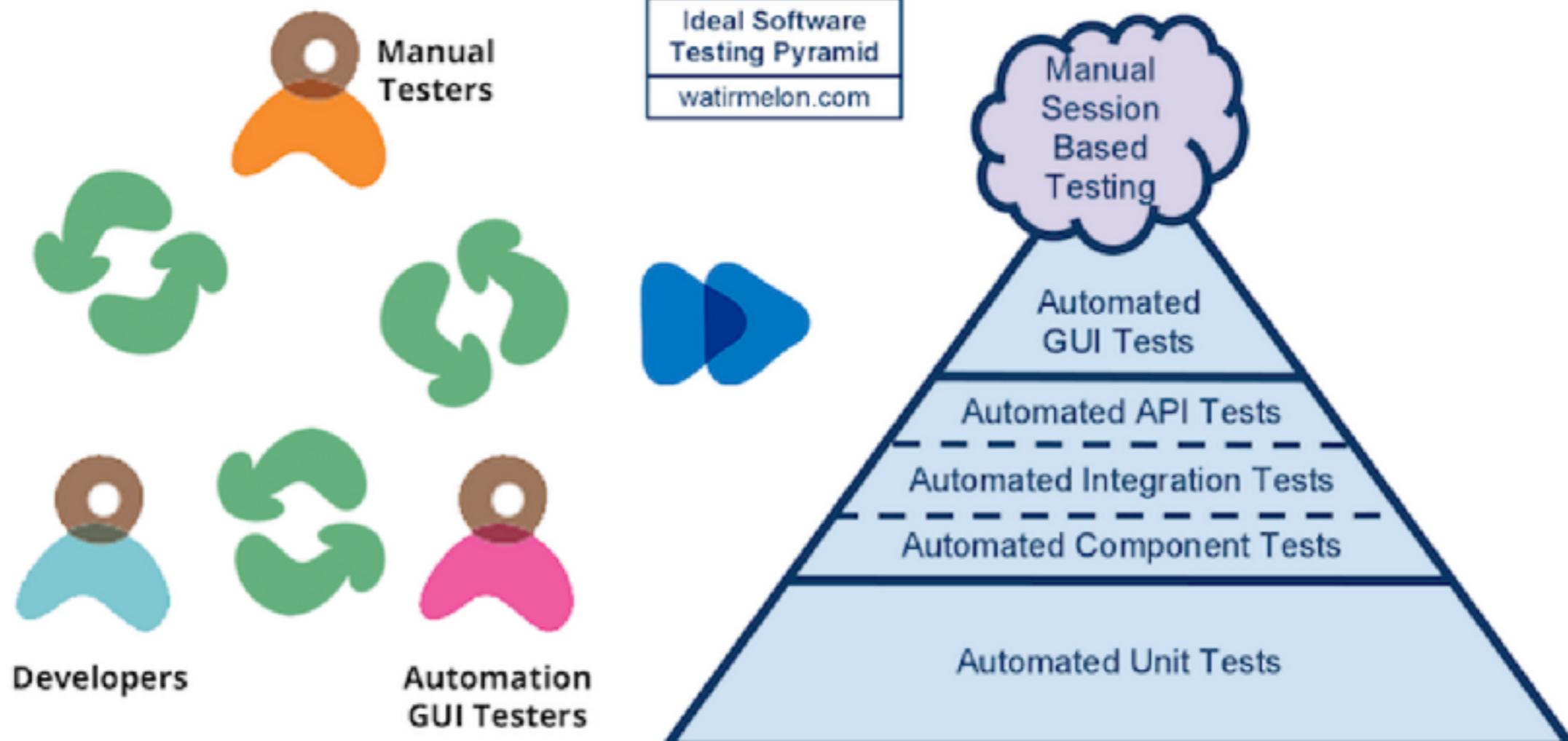
User name	Password	Expected result	Comment
Somkiat	PasswordSomKiat	Access to system as Somkiat	Valid
Som kiat	PasswordSomKiat	Error	Space in user
Somkiat	Password SomKiat	Error	Space in password
Somkiat	1234	Error	Password too short



Workshop

1. Draw a test pyramid
2. Identify tests at each level
3. Think about value (business and customer)
4. What tests should be manual ?





Understand What and How to test ?

Discussion is very important



Remember !!

Test pyramid is a tool
To talk about automation tasks
How to prioritise and help to do automation ?
Way to make **visible to the whole team**



Where to start ?



What are the **biggest**
obstacles ?

Time/Tools/System/People



What should be careful ?

- Automating end-to-end tests
- User Interface are slow
- Working with database
- Working with external system
- Automating every paths



Testing Quadrant



Testing Quadrants

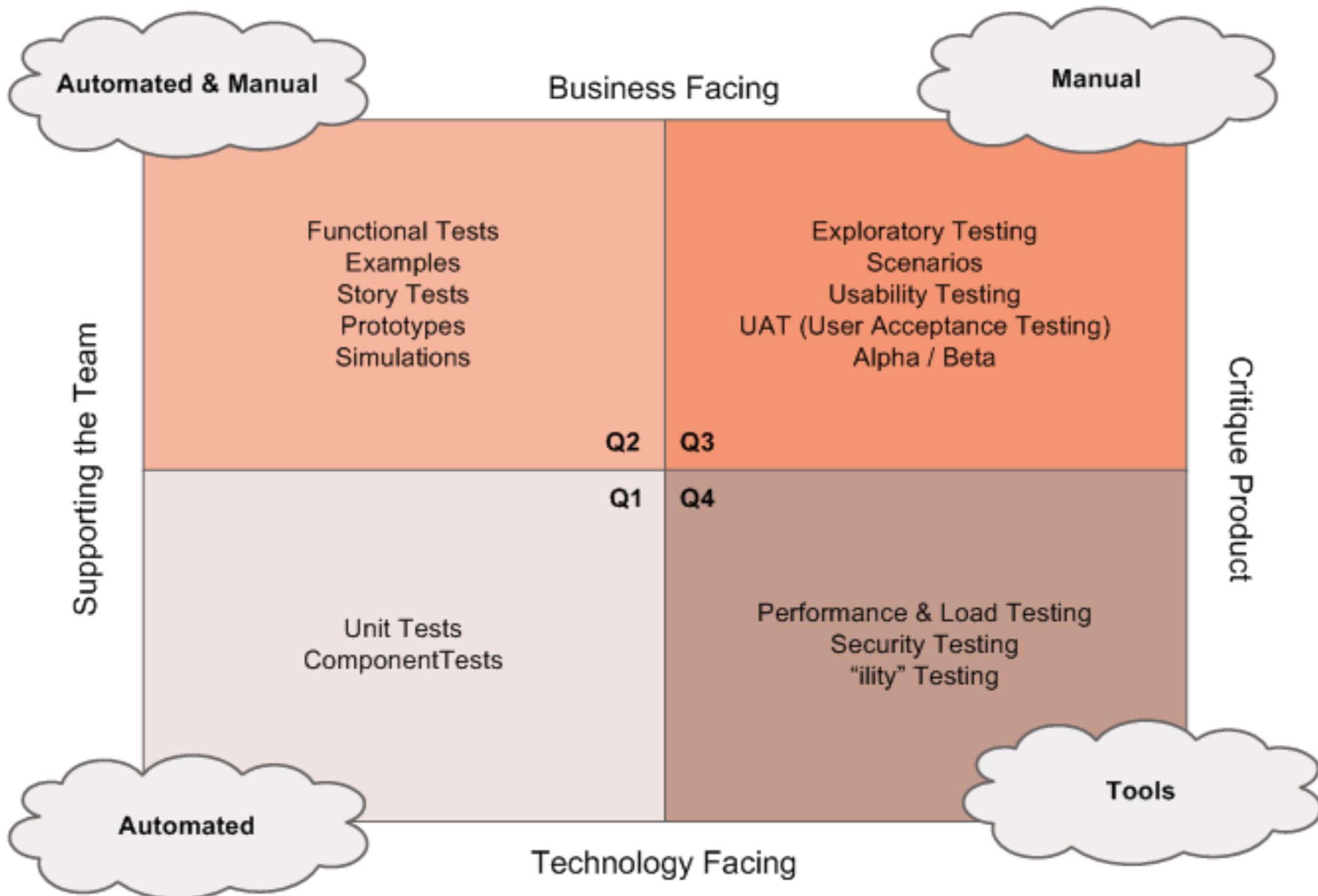
Scope of tests

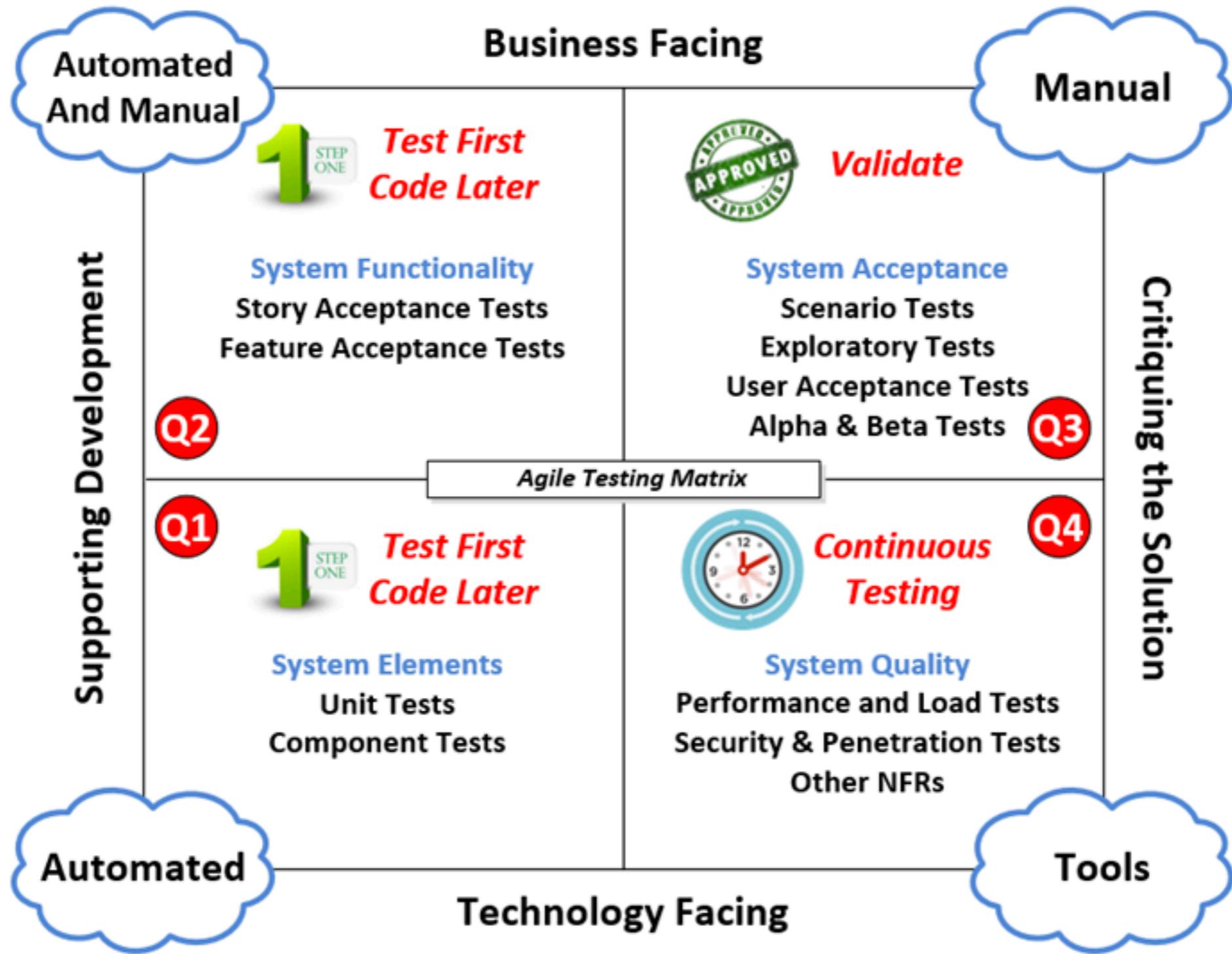
Classify your tests

Visible your tests

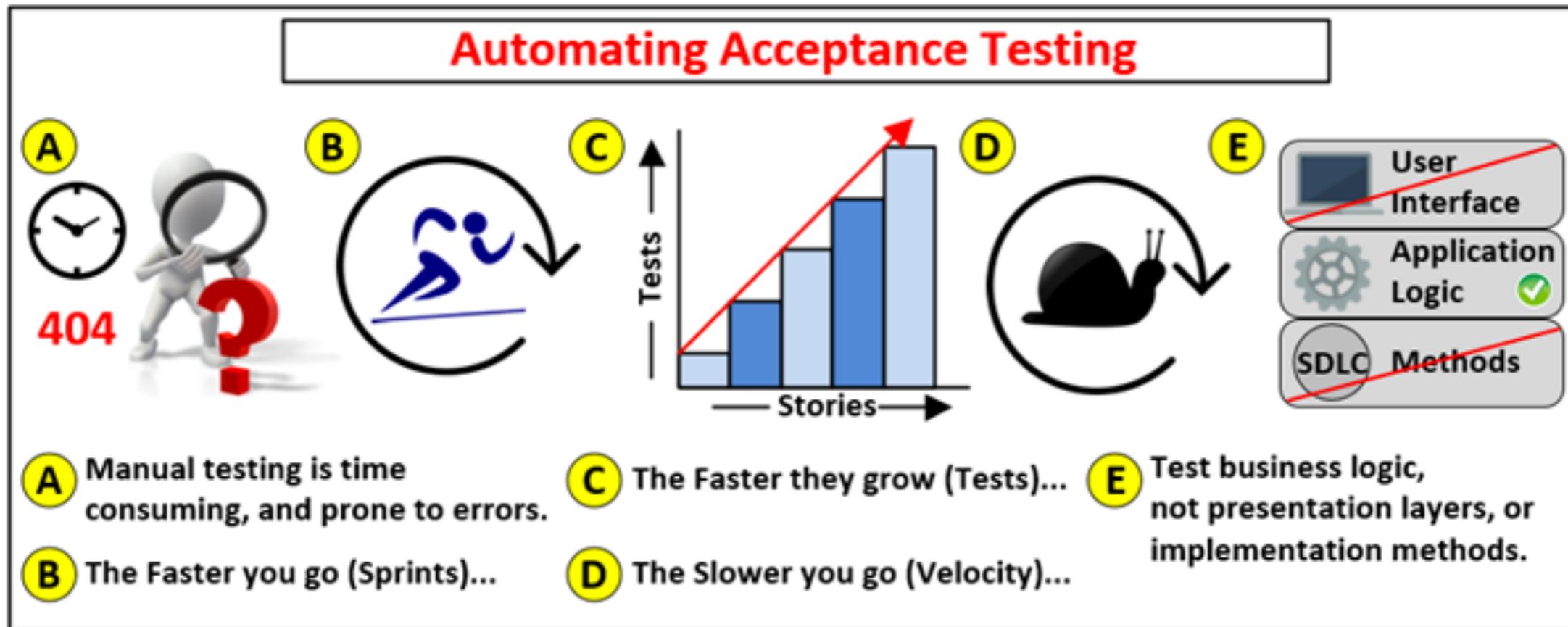


Agile Testing Quadrants





Test automation is essential



Test design



Economy of Test Design

Easy to understand

Easy to maintain

Readable by the business

One purpose per test

Re-runnable



Economy of Test Design

Easy to understand

Easy to maintain

Readable by the business

One purpose per test

Re-runnable

Poor test practices reduce the benefits



Respect your tests

Don't ignore it if it fails

Fix the code or fix the test

100% of regression tests must pass all the time

Always refactor or improve



Test data !!

Avoid database/external system access

Setup/ tear down test data

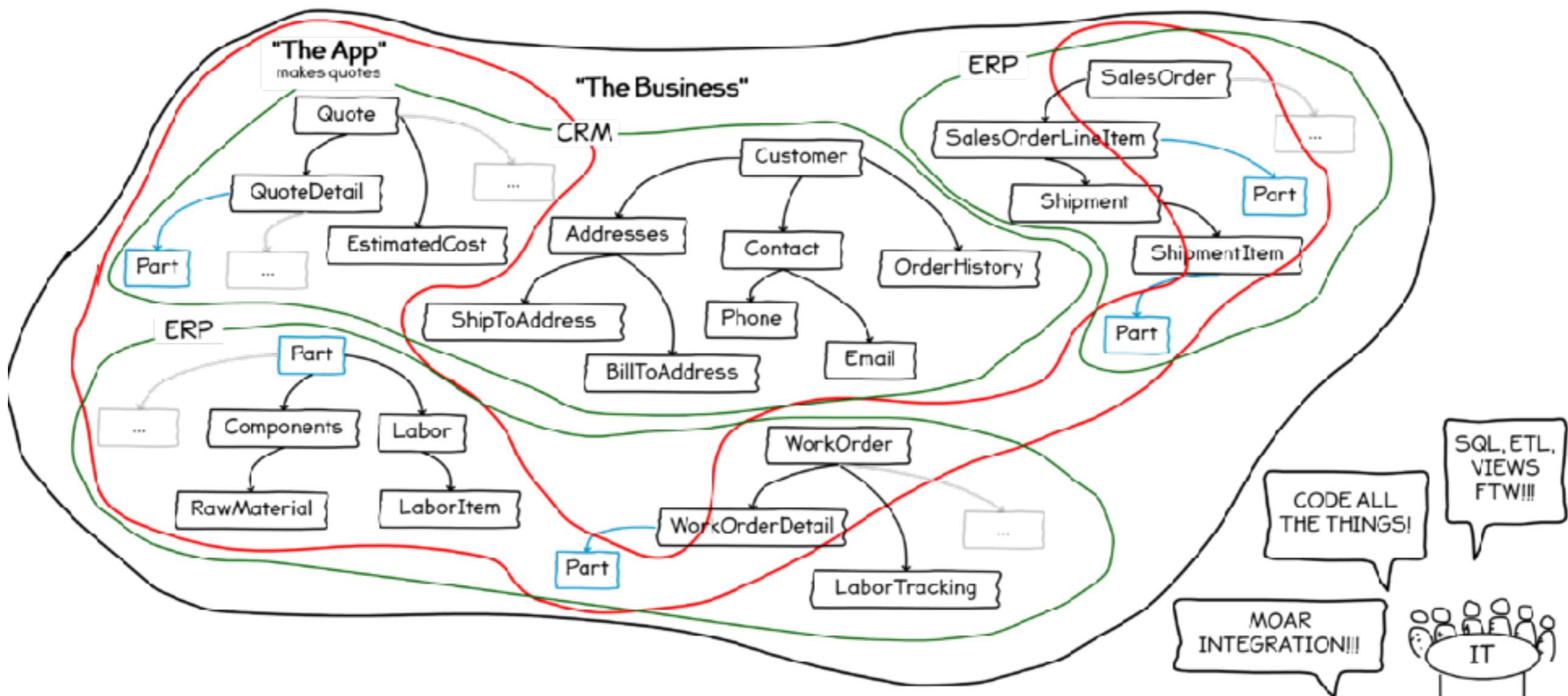
Use production-like data

Need to control your data test



System impacts !!

Know your systems

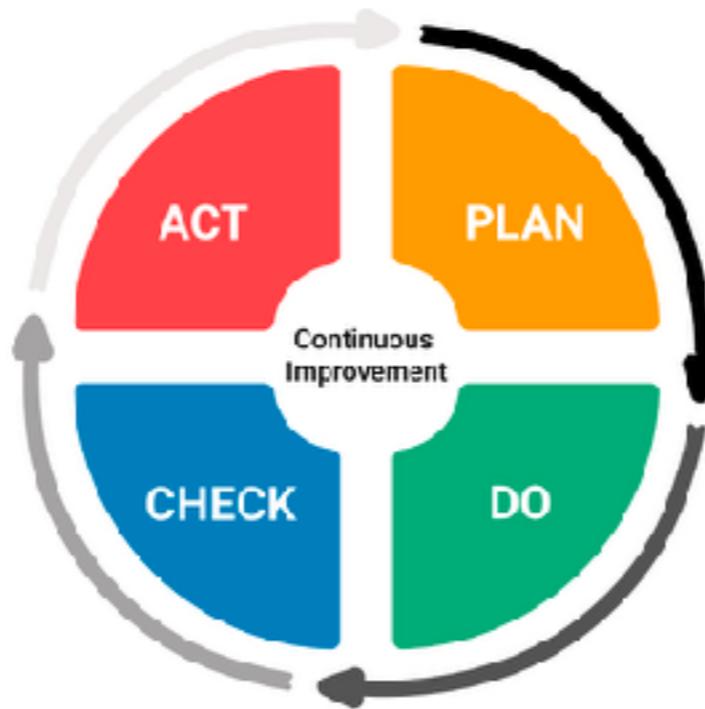


Automation feedback

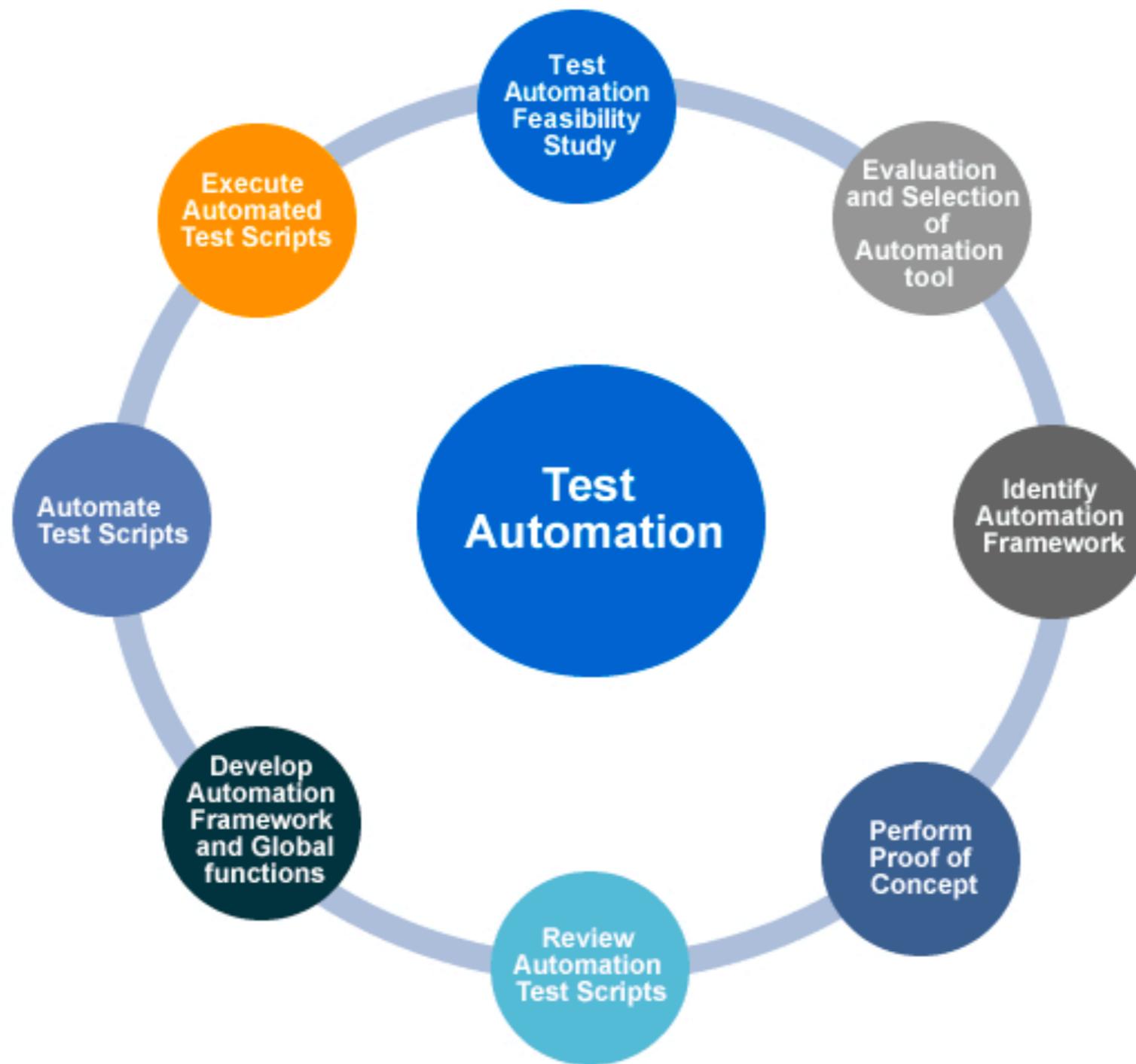
Easier over time ?

Time spent on maintenance ?

Test find regression bugs ?



Test Automation selection



Manage automated tests

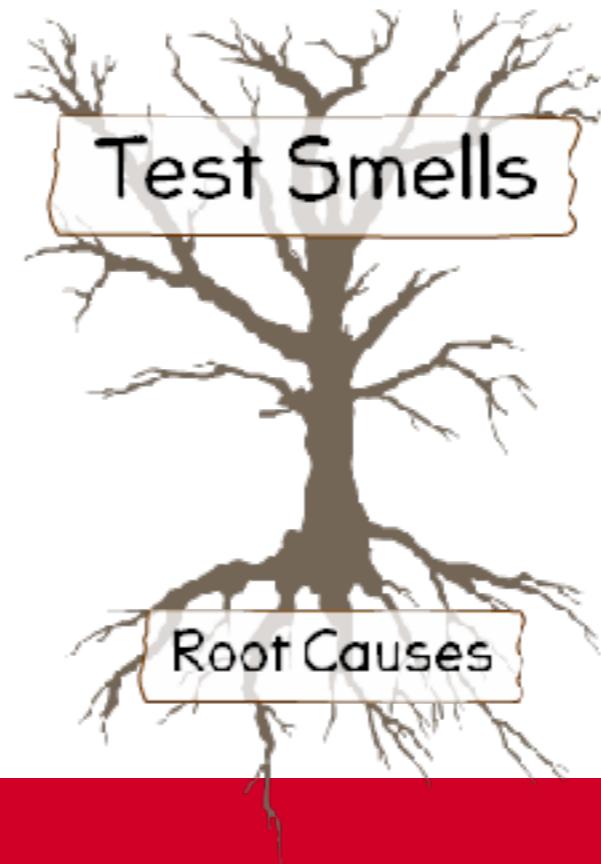
Use source control

Continuous integration to run tests on every change

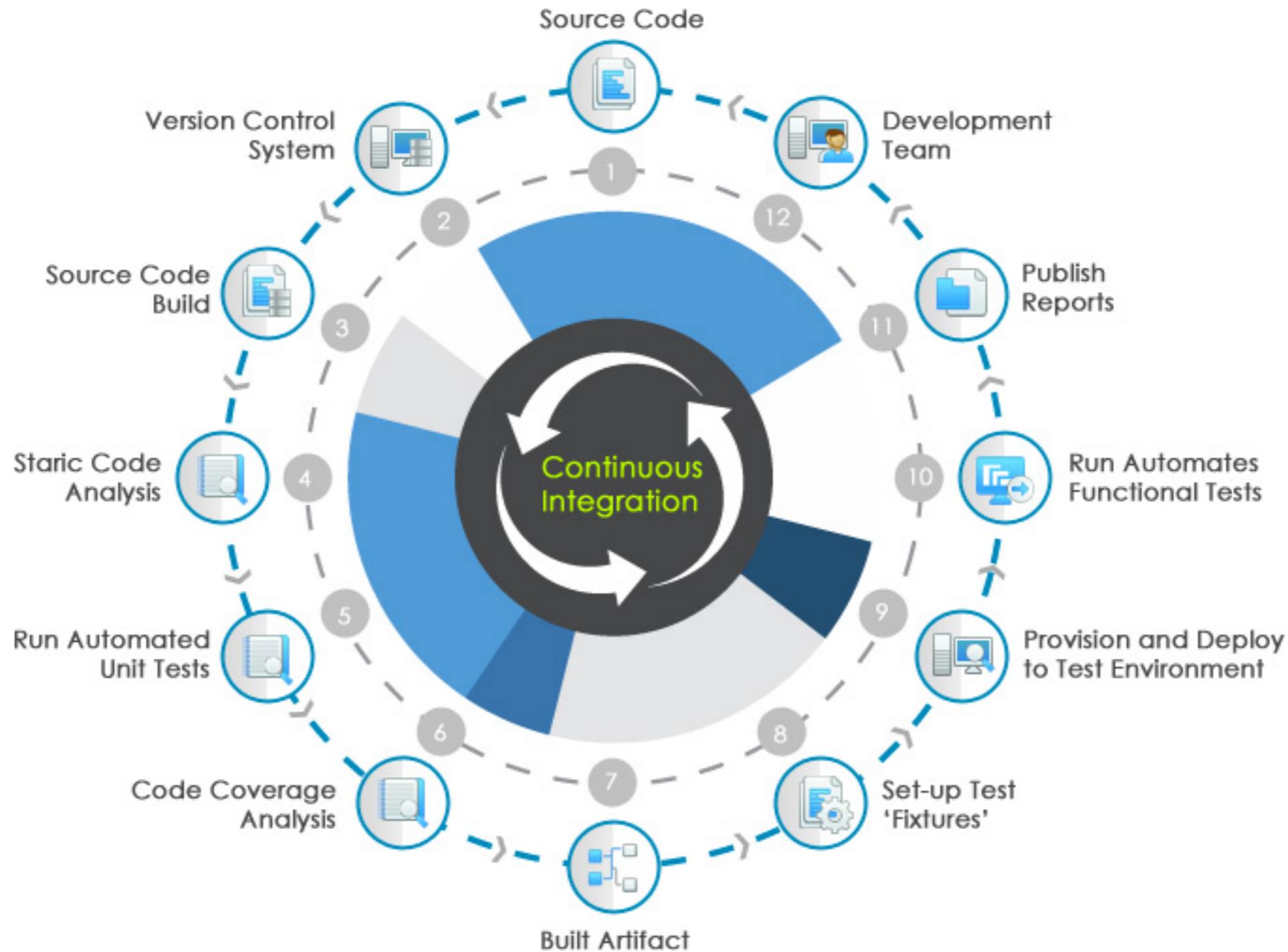
Keep all tests passed

Analyse failures tests

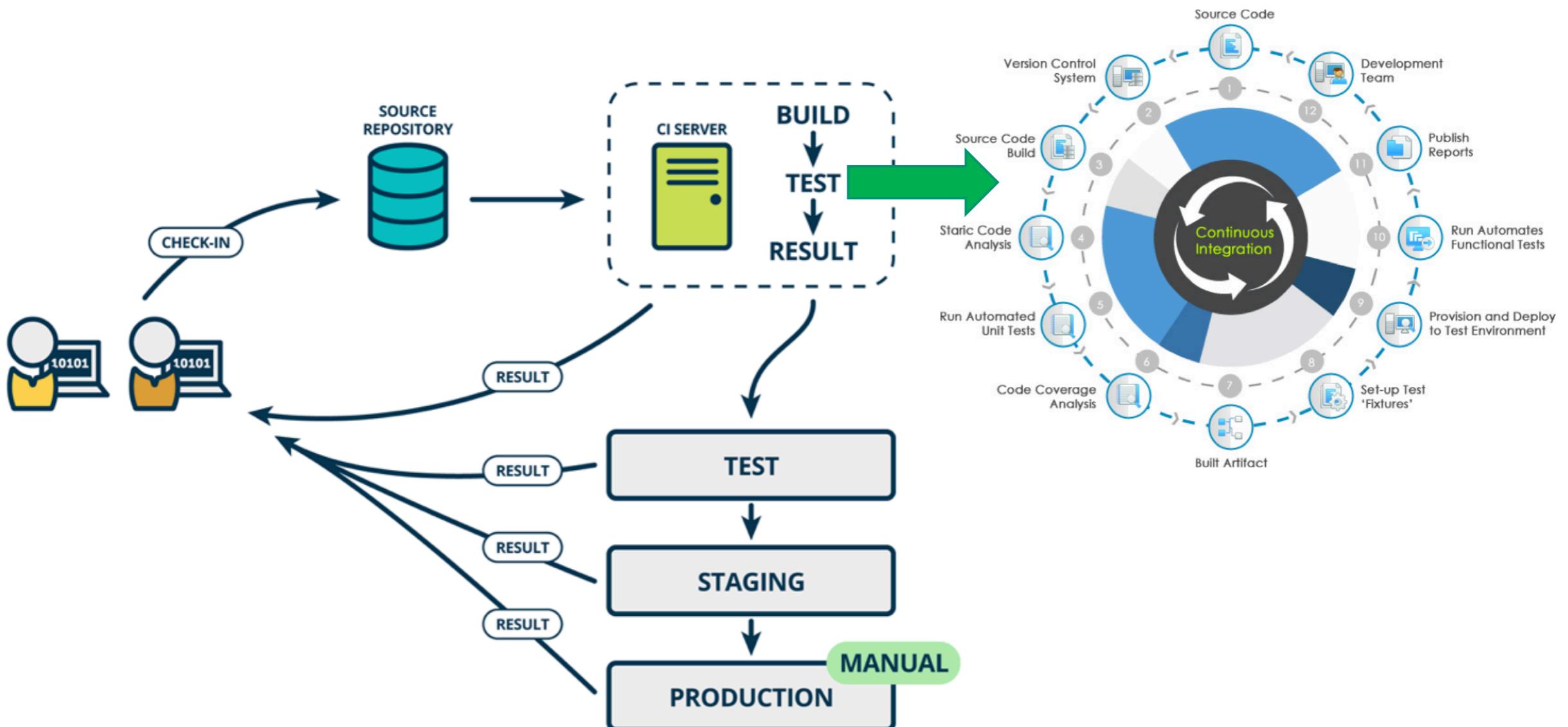
Create test standard



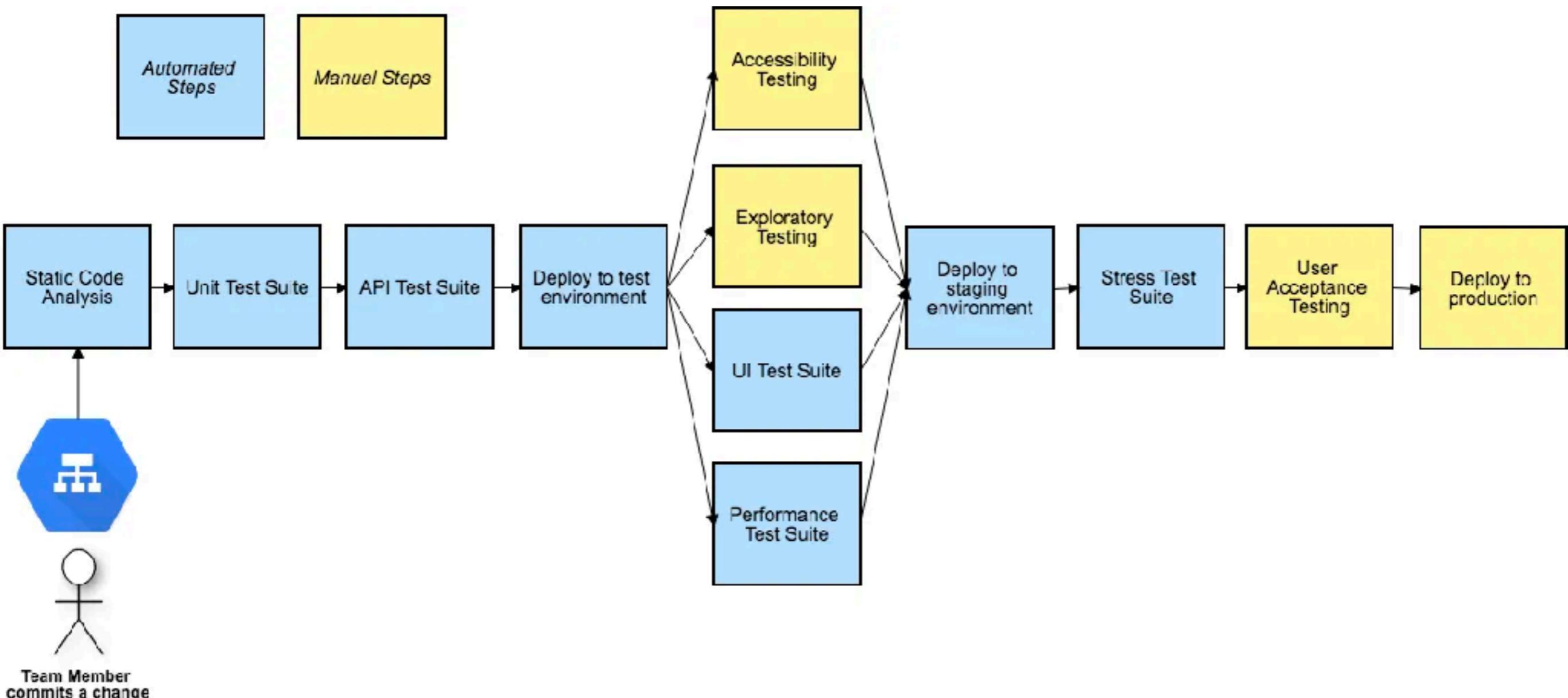
Continuous integration



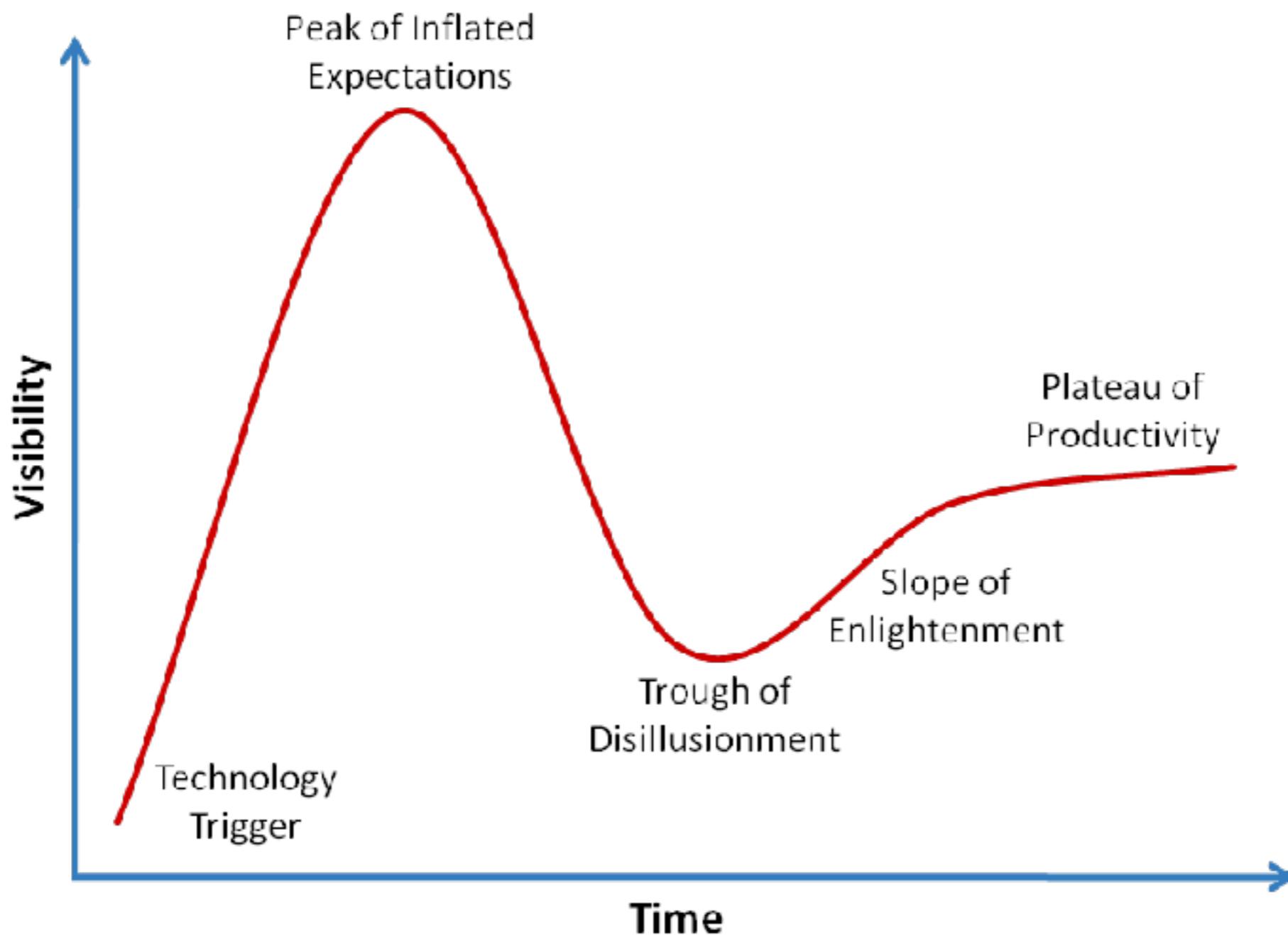
Continuous integration



Design your pipeline/process



Hype cycle



Start with simple



Use **feedback** to improve



Automate Unit Tests



What Unit test ?

Software programs written to exercise other software programs with **specific preconditions** and verify the **expected behaviours**

Usually written in the **same programming language**

Test code

Production
code



What Unit test ?

Small and test only limited line of code functionality

Run very fast (100+ within a few seconds)

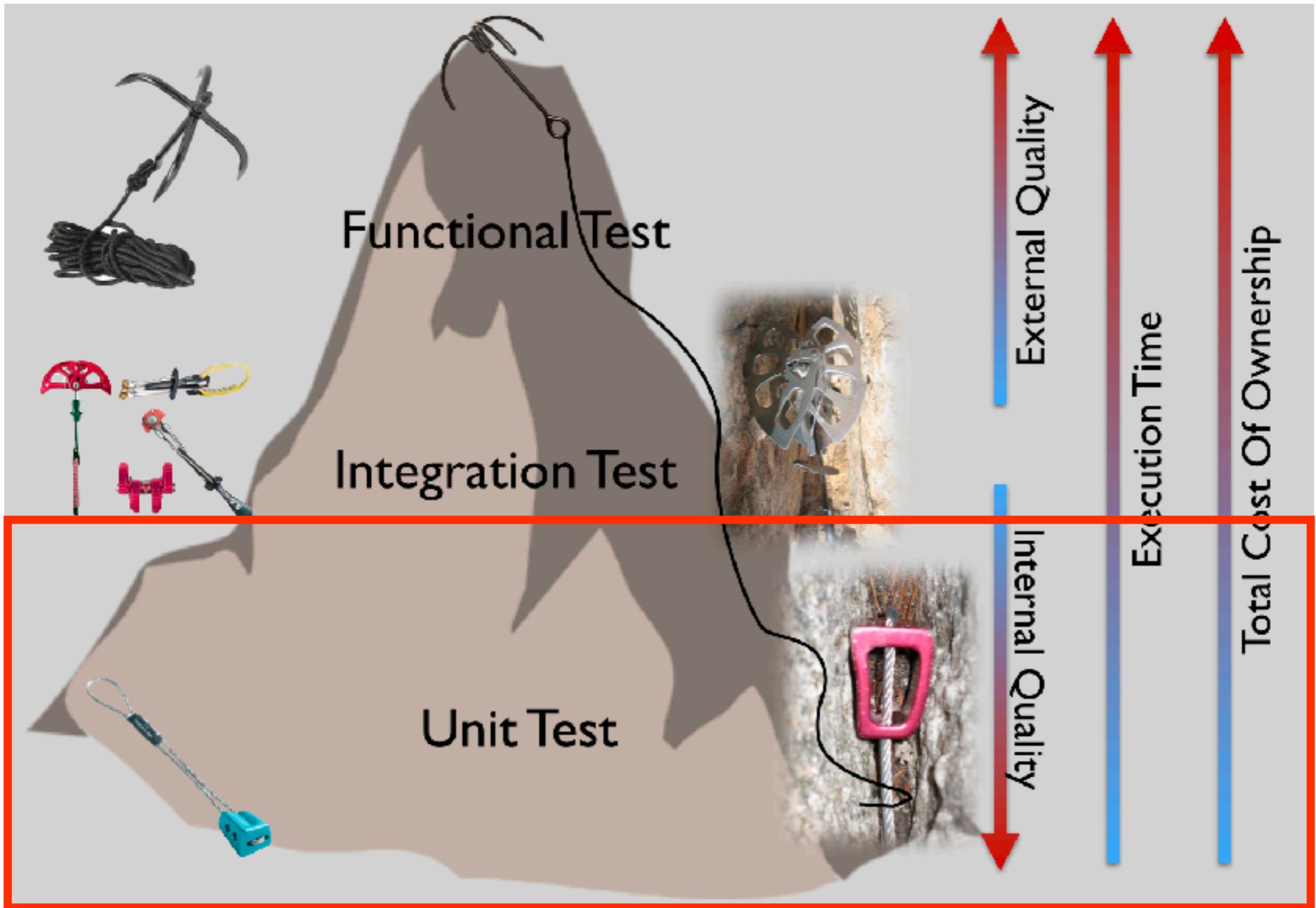


Golden rule of Unit test

Each unit test case should be
very limited in scope

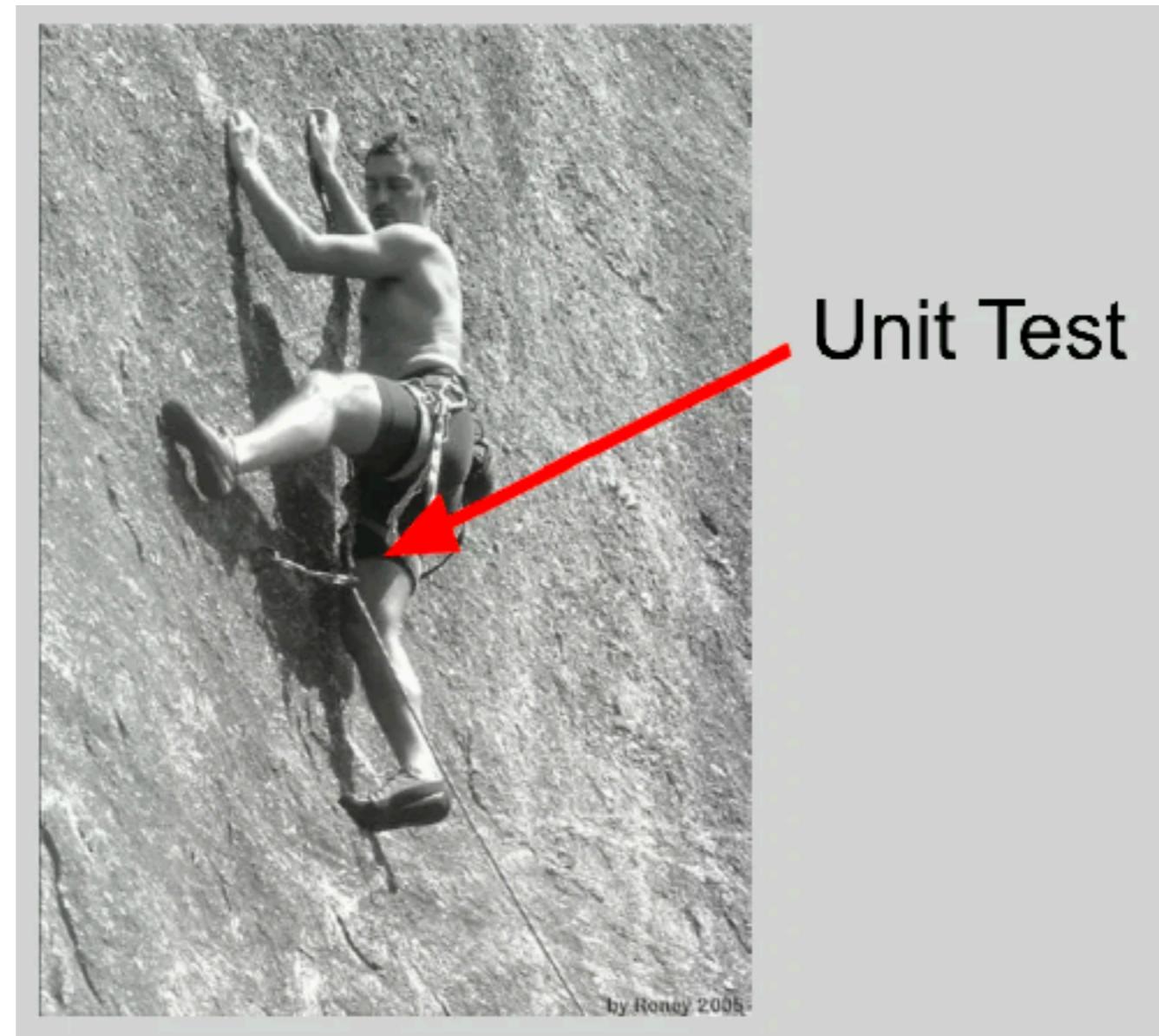


Why Unit test ?



Why Unit test ?

Protect what we have implemented than to find any defects



Unit Test



Purpose of Unit test

Facilitates changes
Simplifies integration
Documentation
Design tool



Good Unit Tests (F.I.R.S.T)

Fast
Independent/Isolate
Repeat
Self-validate
Thorough/Timely



**We need testable code and
easy to test**

Fast feedback



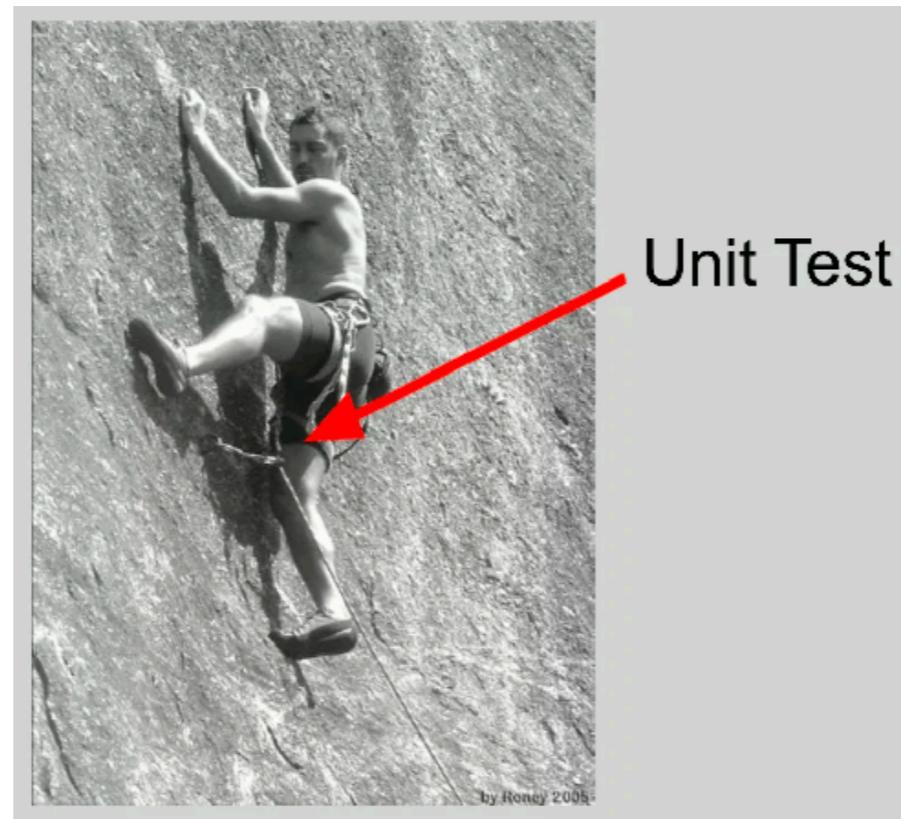
Misconception of Unit test

Not as important as the production code

Done by testing engineers

Write unit test without changing production code

Add unit test later



Maximize test accuracy

Table of error types		Functionality is	
		Correct	Broken
Test result	Test passes	Correct inference (true negatives)	Type II error (false negative)
	Test fails	Type I error (false positive)	Correct inference (true positives)

Resistance to refactoring

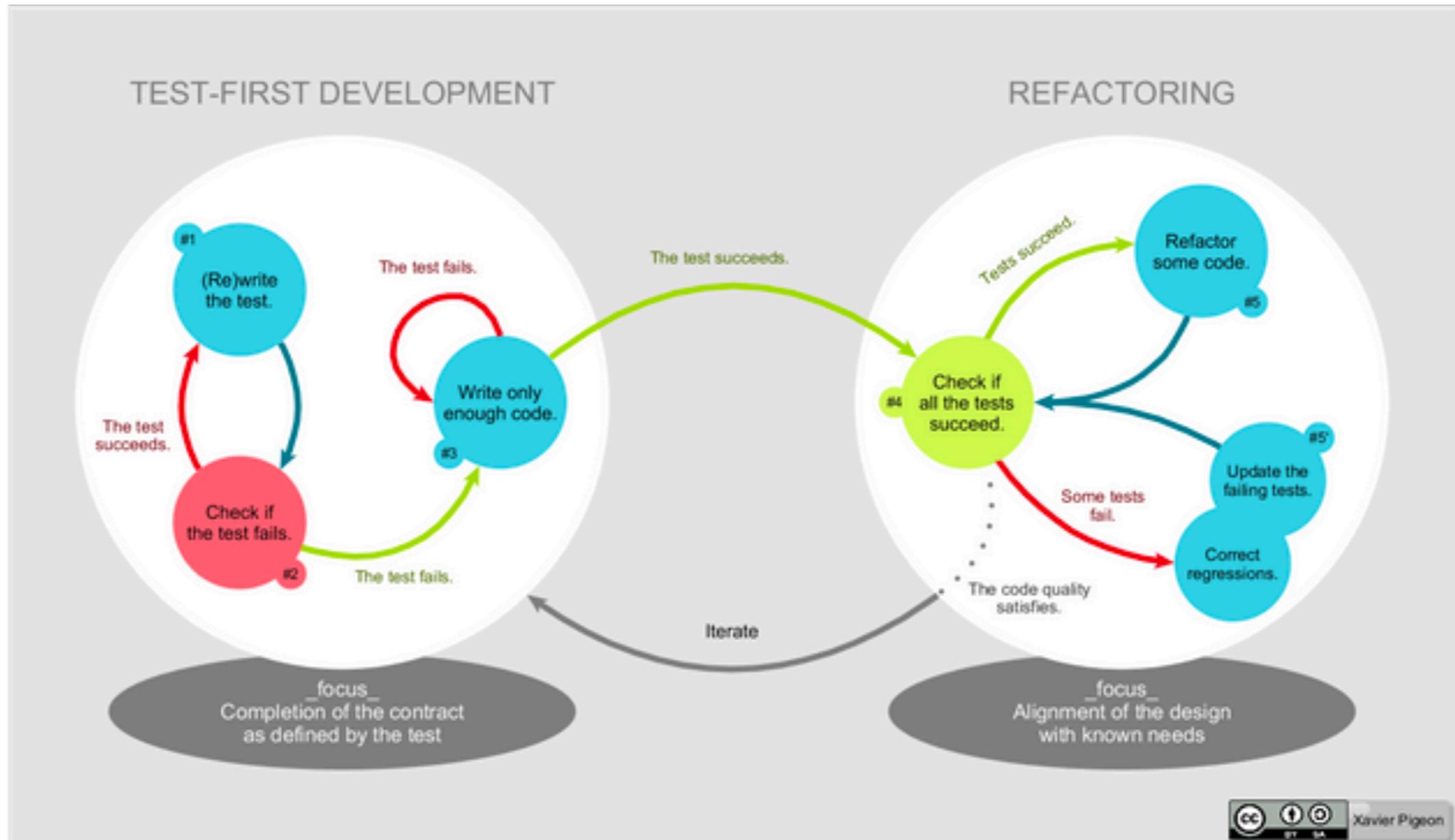
Protection against regressions



Let's start with Test-First



Test-First





TDD

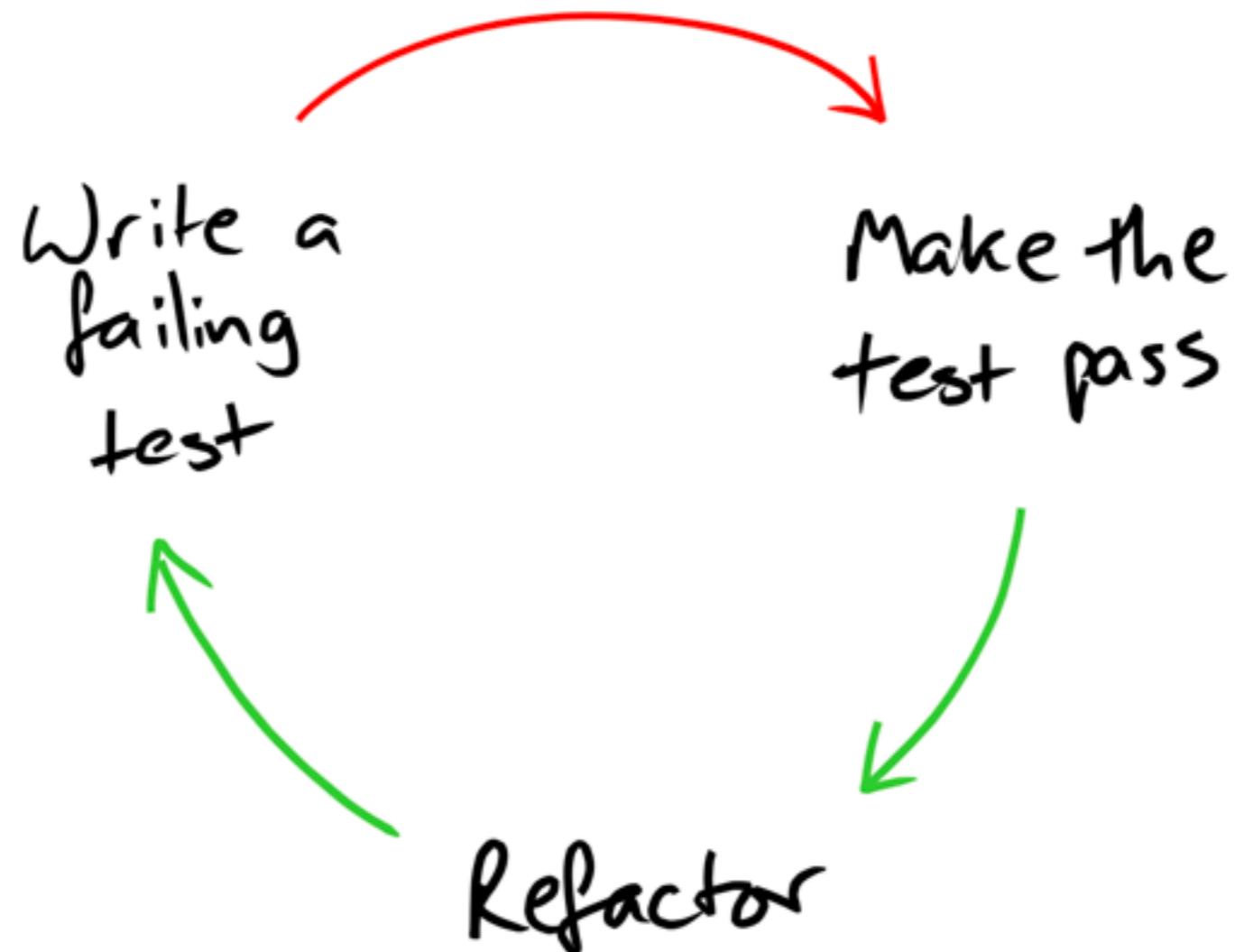
**ALL CODE IS GUILTY
UNTIL PROVEN INNOCENT**



TDD ==> ทำดีดี



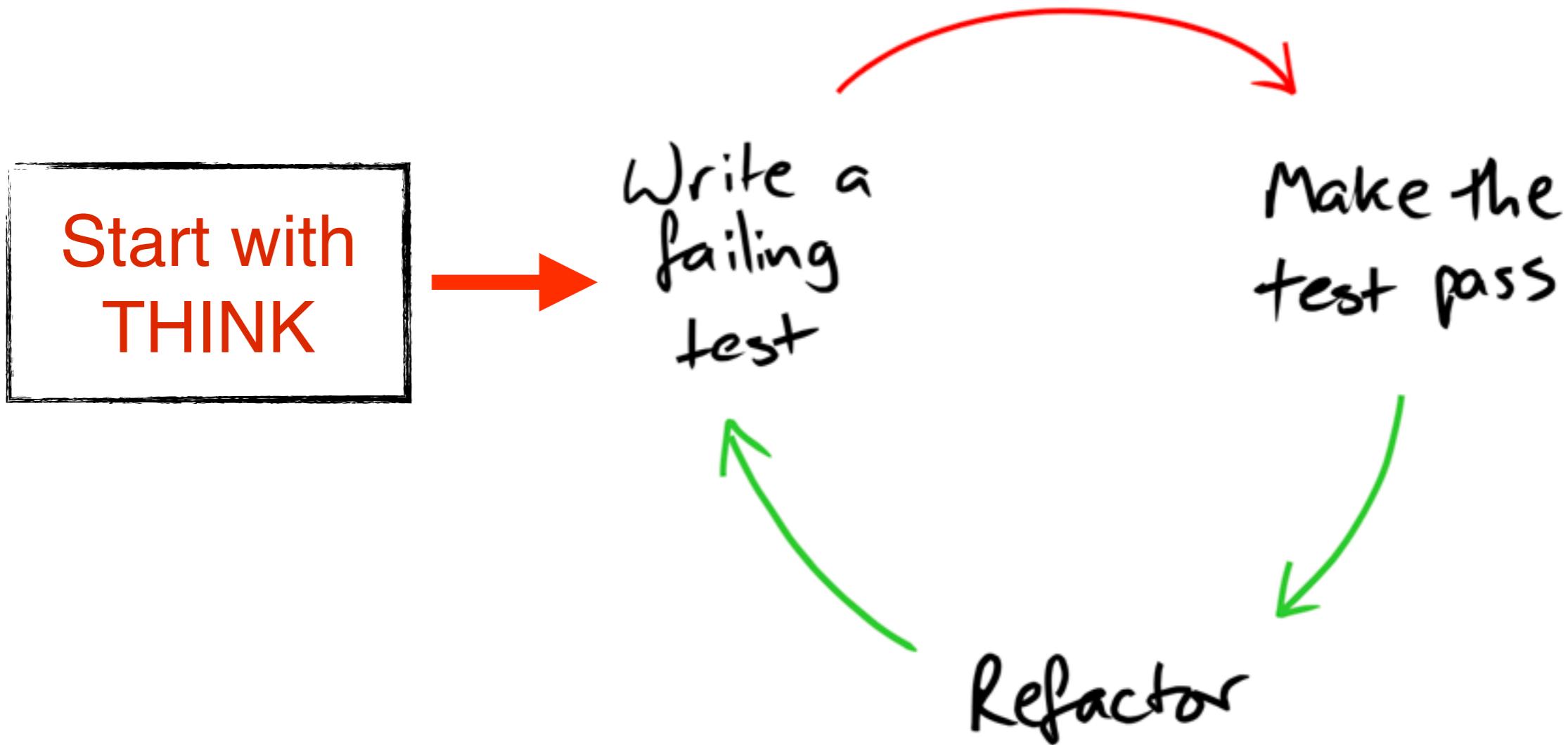
TDD Cycle



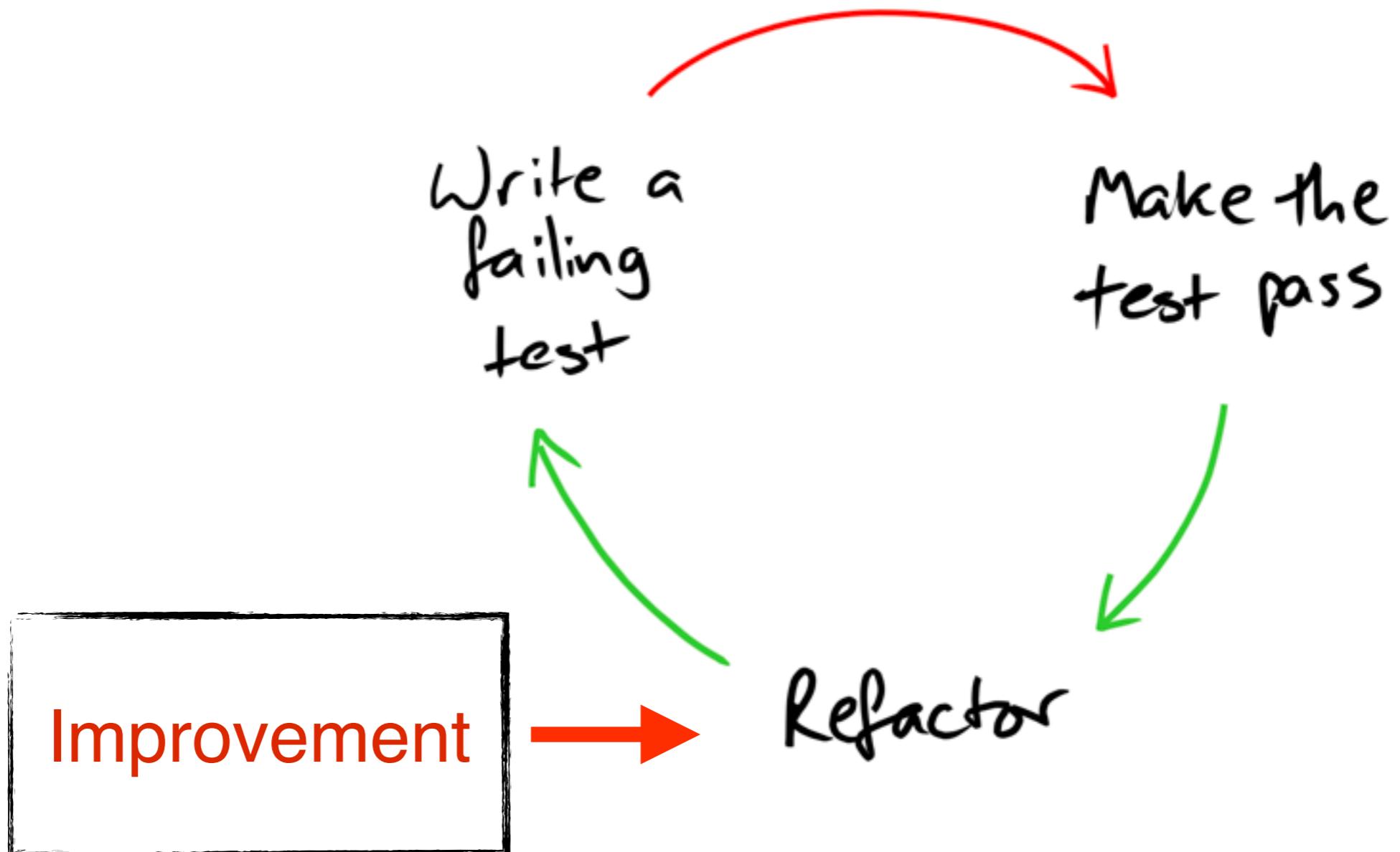
Red Green Refactor



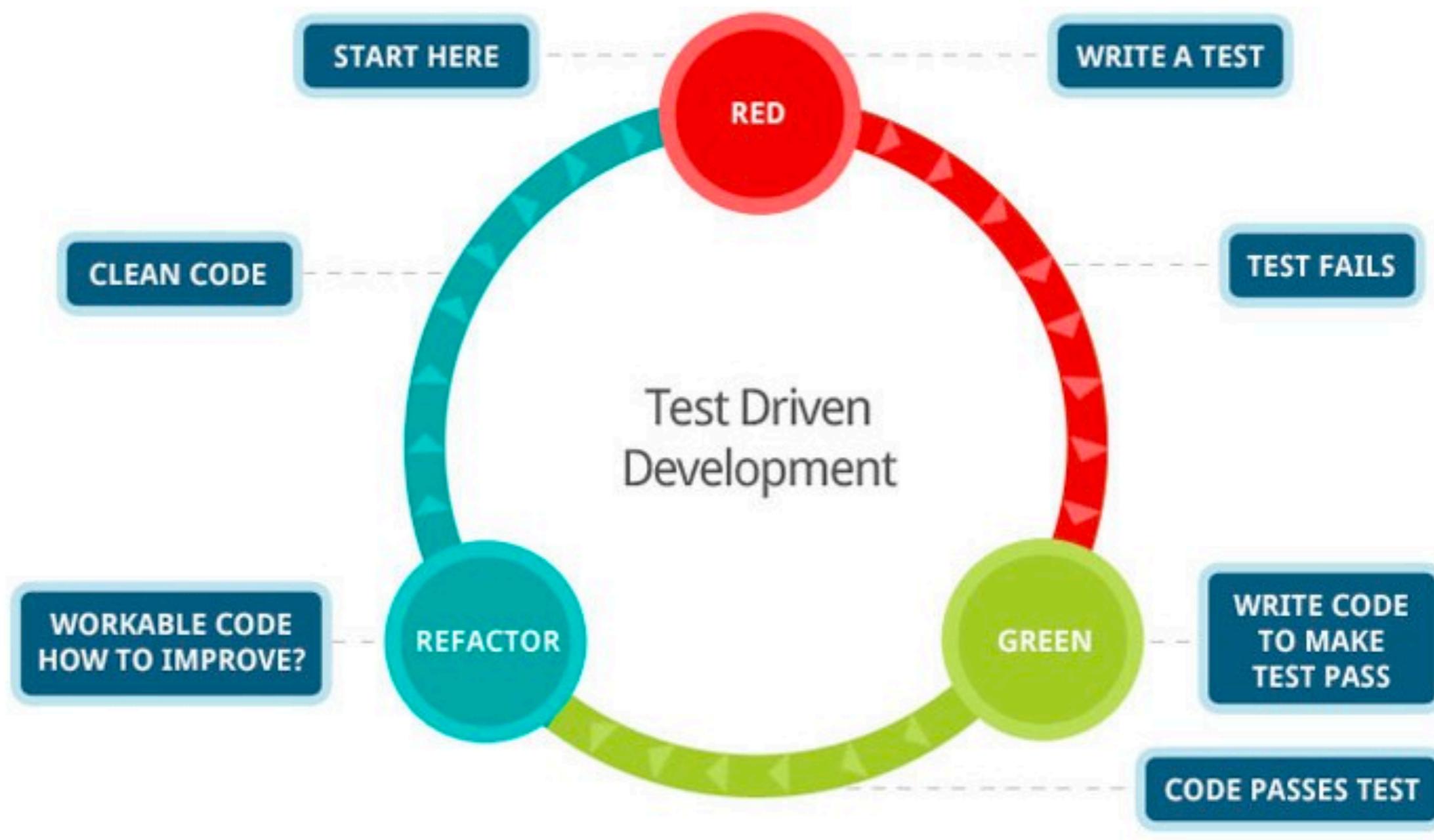
Improve TDD Cycle



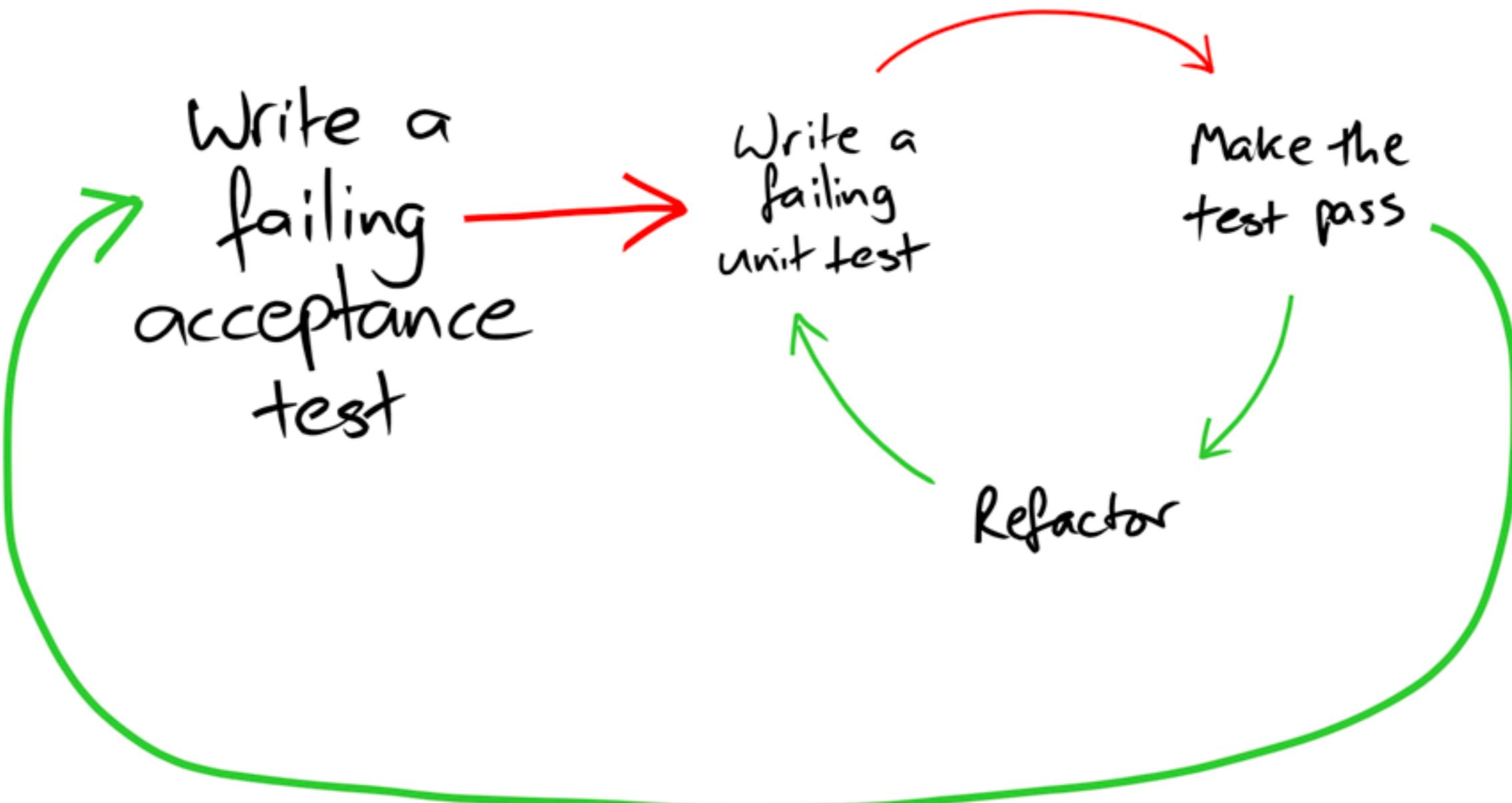
Improve TDD Cycle



Improve TDD Cycle



Acceptance tests



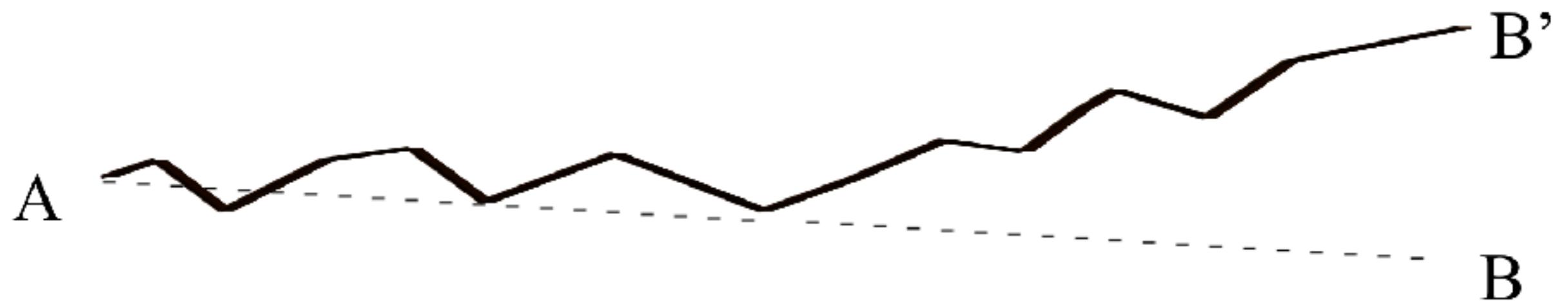
The Golden rule of TDD

“Never write a line of code
without a failing test”

- Kent Beck -



Small Step



Learning Testing Framework

xUnit.net

<https://xunit.net/>



xUnit :: Test structure

Using [Fact] for a test case

```
public class UnitTest1
{
    [Fact]
    public void Test1()
    {

    }
}
```



Run test in command-line

\$dotnet test



Organize your tests

How to make your tests visually **consistent** ?
Keeping tests maintainable by testing behavior
The importance of test naming
Using test's life cycle



Good test structure

1. Setup the test data
2. Call your method under test
3. Assert that the expected results are returns



Good test structure

AAA (Arrange Act Assert)

Given When Then from BDD style

<https://xp123.com/articles/3a-arrange-act-assert/>

<https://www.martinfowler.com/bliki/GivenWhenThen.html>



Good test structure

Using Arrange-Act-Assert

```
public class UnitTest1
{
    [Fact]
    public void Test1()
    {
        // Arrange
        var hello = new Hello();

        // Act
        var actualResult = hello.sayHi();

        // Assert
        Assert.Equal("Hello TDD", actualResult);
    }
}
```



Assertion in xUnit

Check Value

Check type and reference

Exception



Data-Driven testing

Working with [Theory]

[InlineData]

[MemberData]

[ClassData]



Data-Driven testing

Manage data for testing

```
[Theory]
[InlineData(3)]
[InlineData(5)]
[InlineData(6)]
public void MyFirstTheory(int value)
{
    Assert.True(IsOdd(value));
}

bool IsOdd(int value)
{
    return value % 2 == 1;
}
```



Working with Exceptions

Using Record to capture exception

```
[Fact]
public void TestWithException()
{
    // Act
    Exception exception = Record.Exception(
        () => callWithException()
    );
    // Assert
    Assert.NotNull(exception);
}
```

```
void callWithException()
{
    throw new NotImplementedException();
}
```



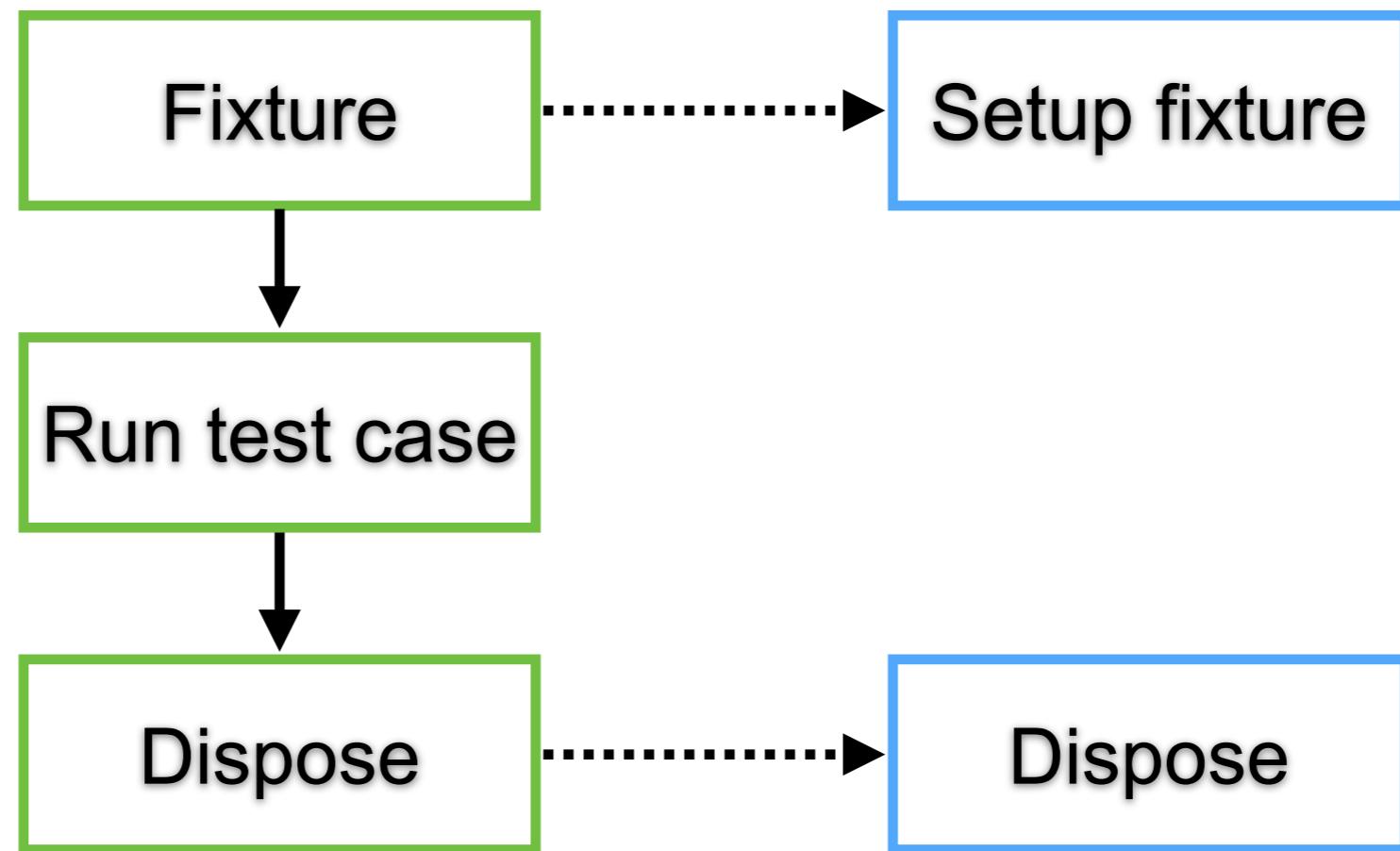
Shared context between tests

Constructor and Dispose
Class Fixtures
Collection Fixtures

<https://xunit.net/docs/shared-context>



Testing life-cycle



Testing life-cycle

Using **Dispose** for cleanup in each test case

```
public class UnitTest2: IDisposable
{
    public UnitTest2()
    {
        Console.WriteLine("Called UnitTest2");
    }
    public void Dispose()
    {
        Console.WriteLine("Called Dispose");
    }

    [Fact]
    public void Test1()
    {
        Console.WriteLine("Called Test1");
    }
}
```

Called UnitTest2
Called Test2
Called Dispose
Called UnitTest2
Called Test1
Called Dispose



Compare with other frameworks

NUnit 3.x	MSTest 15.x	xUnit.net 2.x	Comments
[Test]	[TestMethod]	[Fact]	Marks a test method.
[TestFixture]	[TestClass]	n/a	xUnit.net does not require an attribute for a test class; it looks for all test methods in all public (exported) classes in the assembly.
Assert.That Record.Exception	[ExpectedException]	Assert.Throws Record.Exception	xUnit.net has done away with the ExpectedException attribute in favor of Assert.Throws . See Note 1
[SetUp]	[TestInitialize]	Constructor	We believe that use of [SetUp] is generally bad. However, you can implement a parameterless constructor as a direct replacement. See Note 2
[TearDown]	[TestCleanup]	IDisposable.Dispose	We believe that use of [TearDown] is generally bad. However, you can implement IDisposable.Dispose as a direct replacement. See Note 2
[OneTimeSetUp]	[ClassInitialize]	IClassFixture<T>	To get per-class fixture setup, implement IClassFixture<T> on your test class. See Note 3
[OneTimeTearDown]	[ClassCleanup]	IClassFixture<T>	To get per-class fixture teardown, implement IClassFixture<T> on your test class. See Note 3
n/a	n/a	ICollectionFixture<T>	To get per-collection fixture setup and teardown, implement ICollectionFixture<T> on your test collection. See Note 3
[Ignore("reason")]	[Ignore]	[Fact(Skip="reason")]	Set the Skip parameter on the [Fact] attribute to temporarily skip a test.
[Property]	[TestProperty]	[Trait]	Set arbitrary metadata on a test
[Theory]	[DataSource]	[Theory] [XxxData]	Theory (data-driven test). See Note 4

<https://xunit.net/docs/comparisons>



Workshop

Input	Expected result
[1, 5]	1,2,3,4,5
[1, 5)	1,2,3,4
(1, 5]	2,3,4,5
(1, 5)	2,3,4

<http://codingdojo.org/kata/Range/>



Code coverage



**"Code coverage can show the
high risk areas in a program,
but never the risk-free."**

Paul Reilly, 2018, Kotlin TDD with Code Coverage



Code coverage

A tool to measure how much of your code is covered by tests that break down into classes, methods and lines.



Code coverage

```
1. public class Hello {  
2.     public String say(String demo) {  
3.         if(demo == null) {  
4.             throw new SomeException();  
5.         }  
6.         return "Hello " + demo;  
7.     }  
8. }  
9.
```



Code coverage

But 100% of code coverage **does not mean** that your code is 100% correct



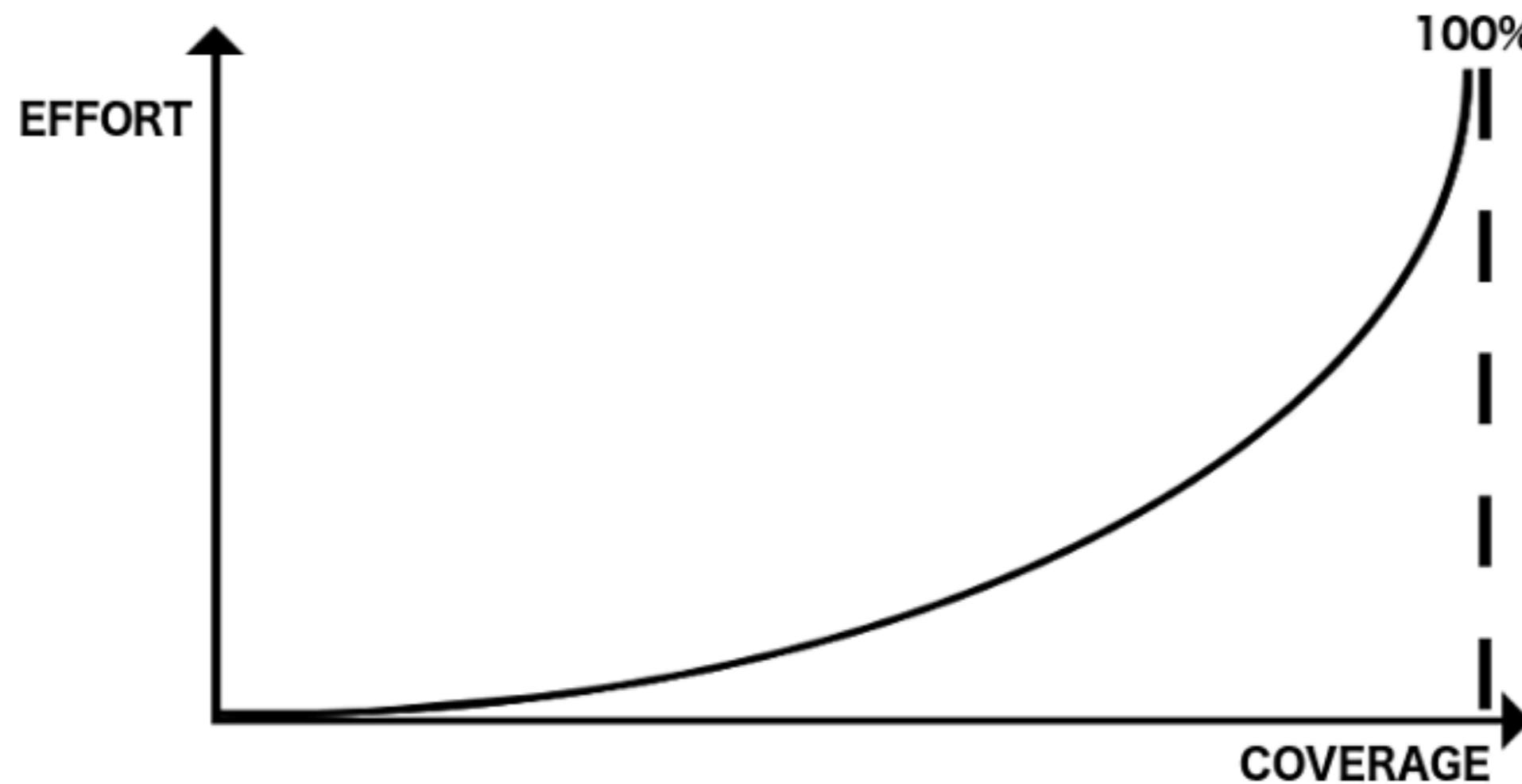
Code coverage

Powerful tool to improve the quality of your code

Code coverage != quality of tests



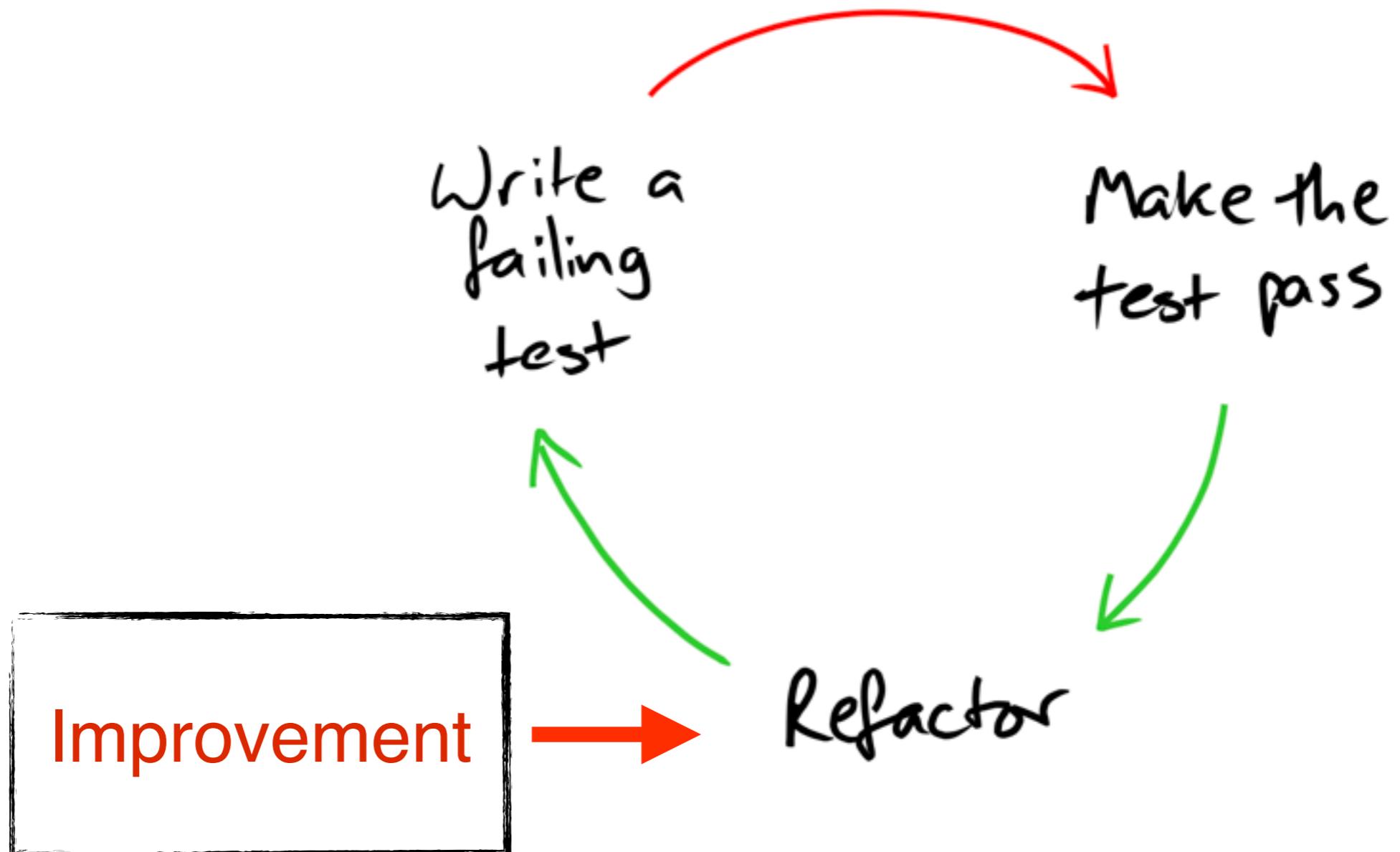
Code coverage 100% ?

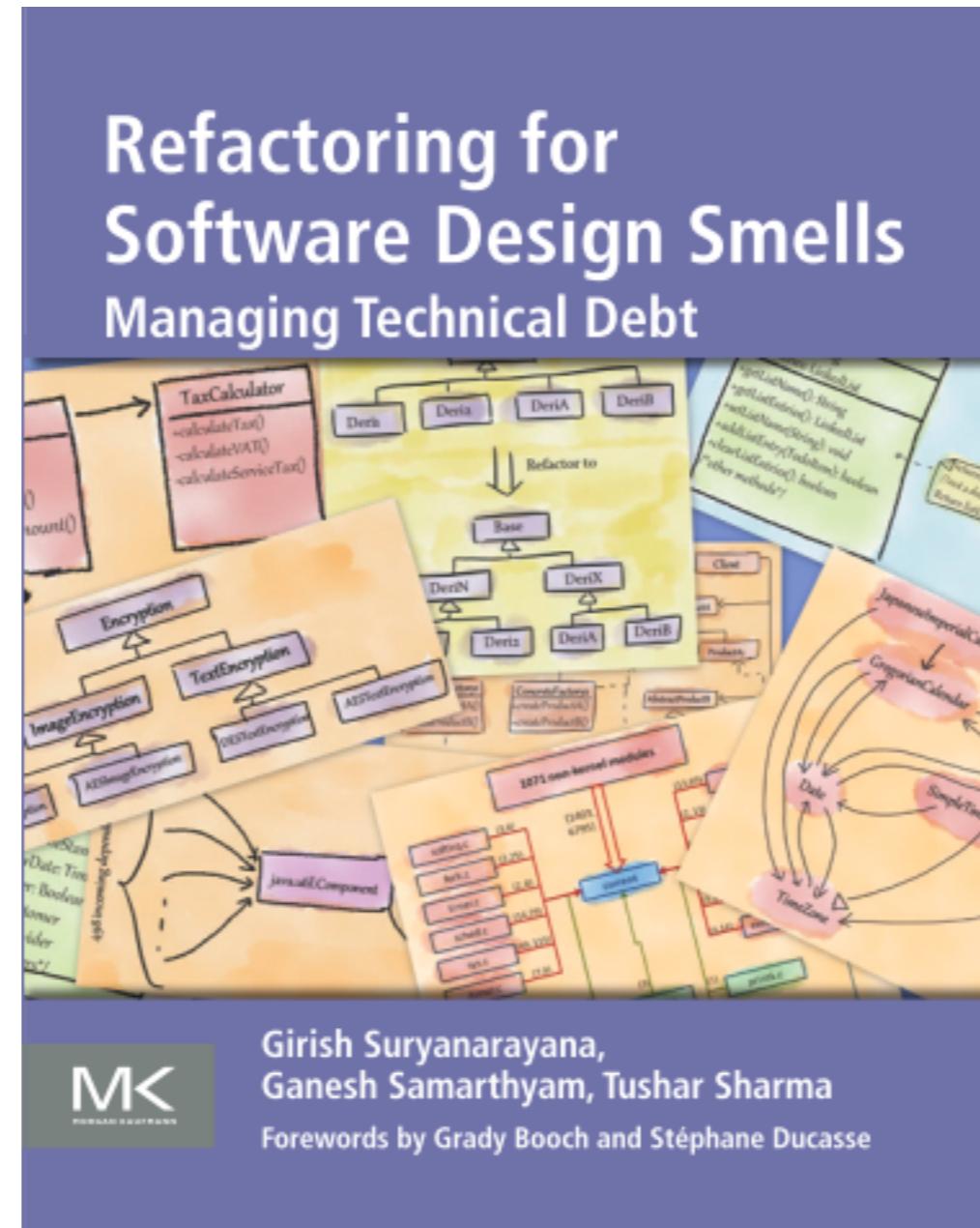


Don't forgot Refactoring



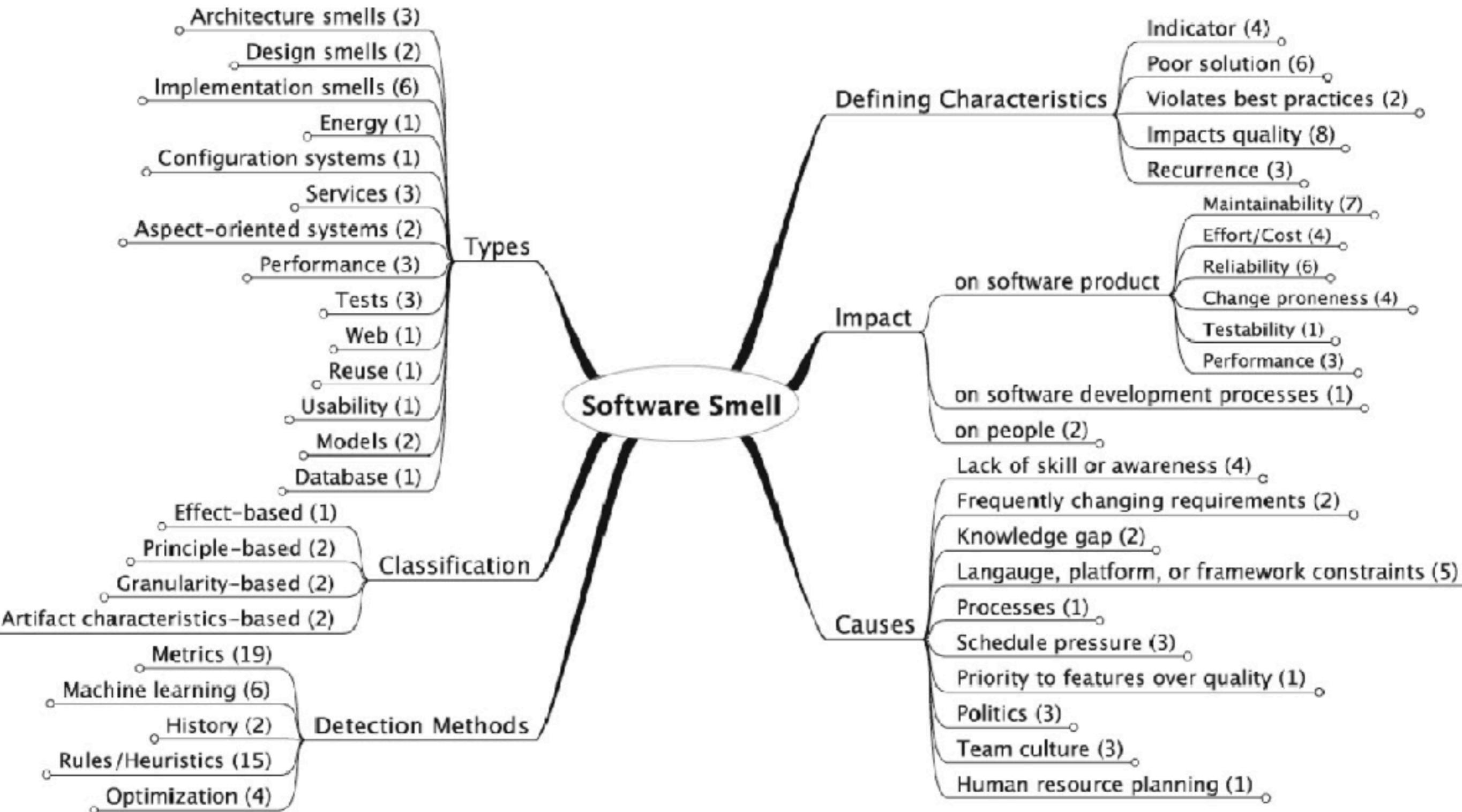
Improve TDD Cycle





<http://www.tusharma.in/smells/>





<https://www.sciencedirect.com/science/article/pii/S0164121217303114>



Code Smell



Code Smells

- What? How can code "smell"??
- Well it doesn't have a nose... but it definitely can stink!



Bloaters

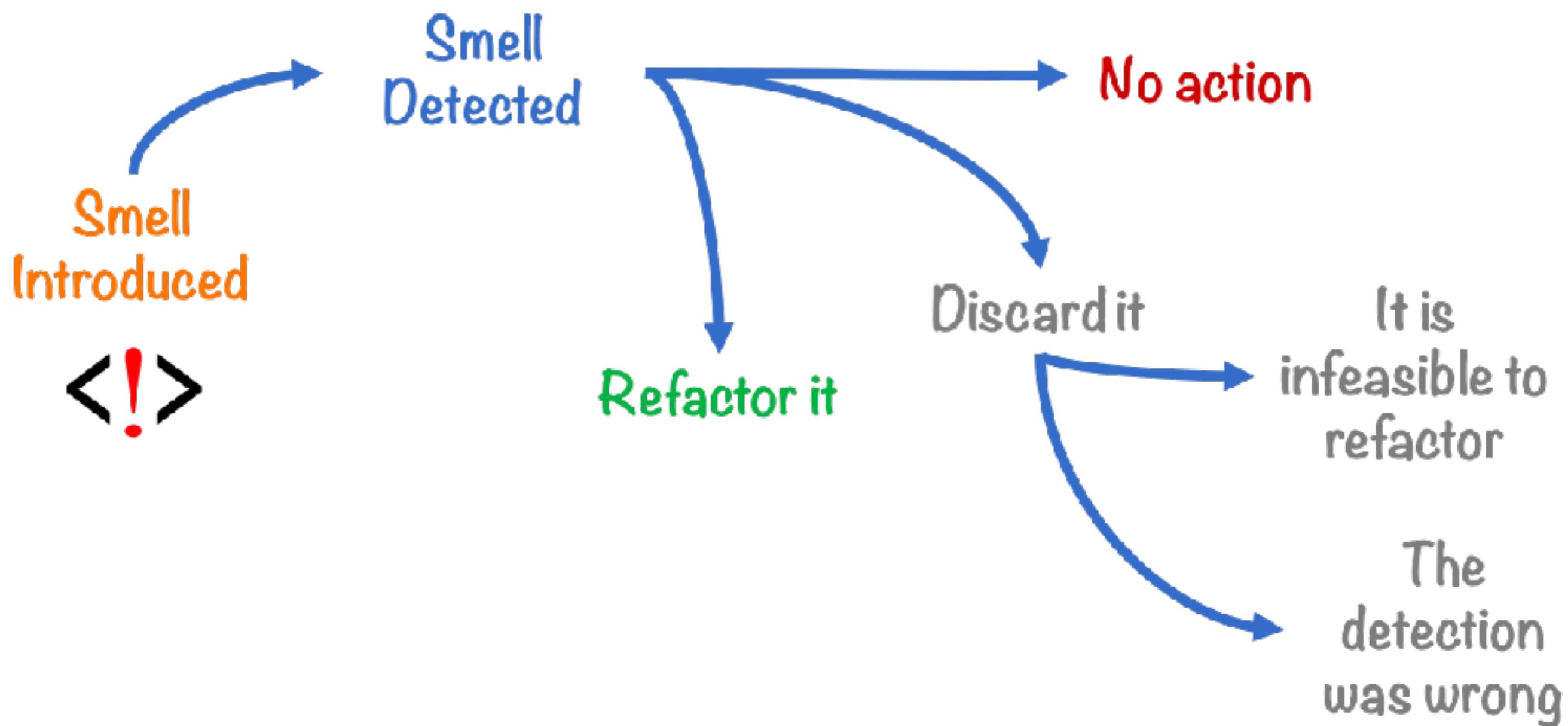
Bloaters are code, methods and classes that have increased to such gargantuan proportions that they are hard to work with. Usually these smells do not crop up right away, rather they accumulate over time as the program evolves (and especially when nobody makes an effort to eradicate them).

- Long Method
- Large Class
- Primitive Obsession
- Long Parameter List
- Data Clumps

<https://sourcemaking.com/refactoring/smells>



Life-cycle of a smell



Workshop



<https://codingdojo.org/kata/Tennis/>



Test as Design



Workshop



<http://codingdojo.org/kata/Potter/>



S.O.L.I.D principles



S.O.L.I.D



SOLID

Software development is not a Jenga game.



Single Responsibility Principle



Single Responsibility Principle

Just because you *can* doesn't mean you *should*.



Open-Closed Principle



Open-Closed Principle

Open-chest surgery isn't needed when putting on a coat.



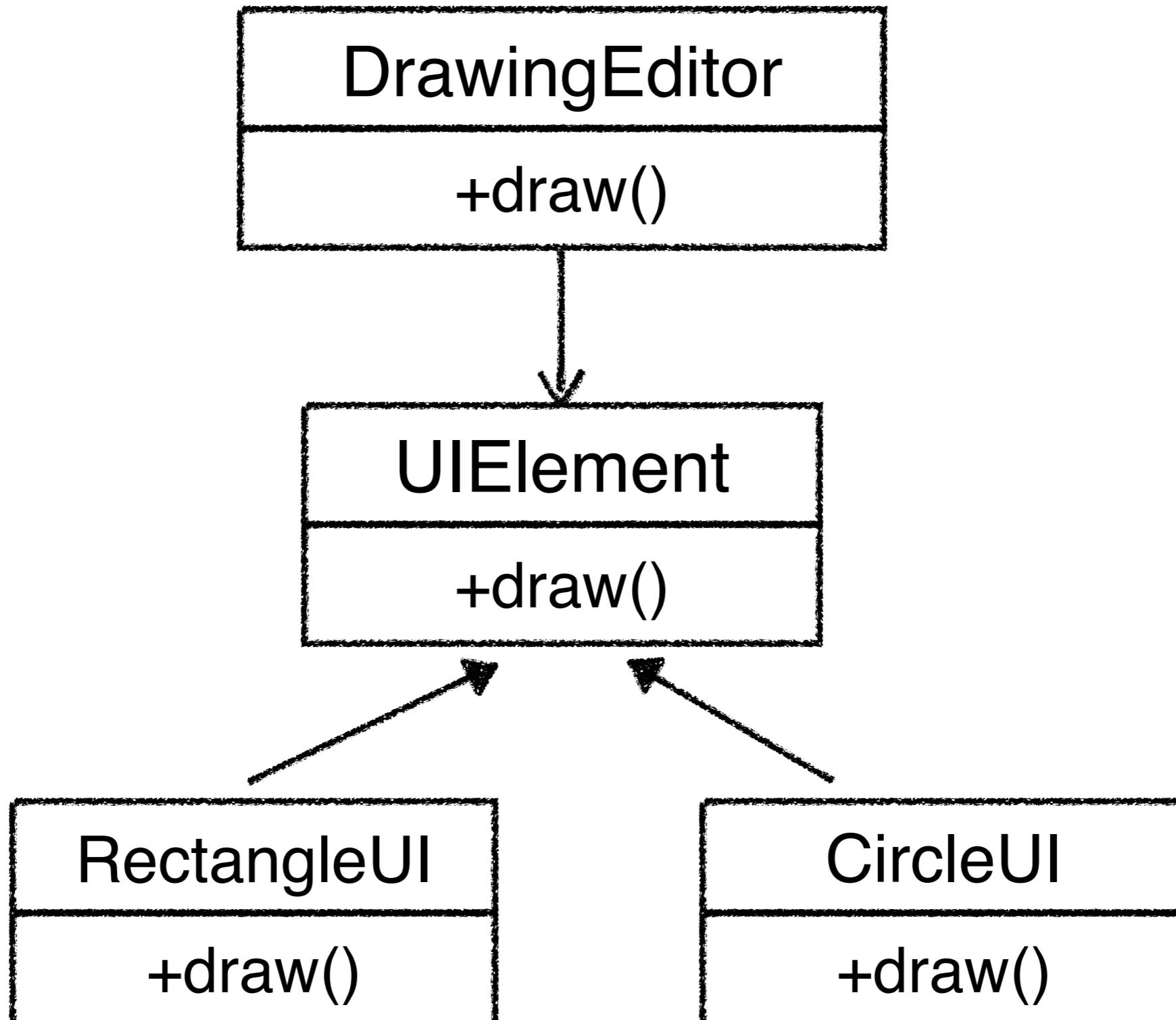
Example

DrawingEditor

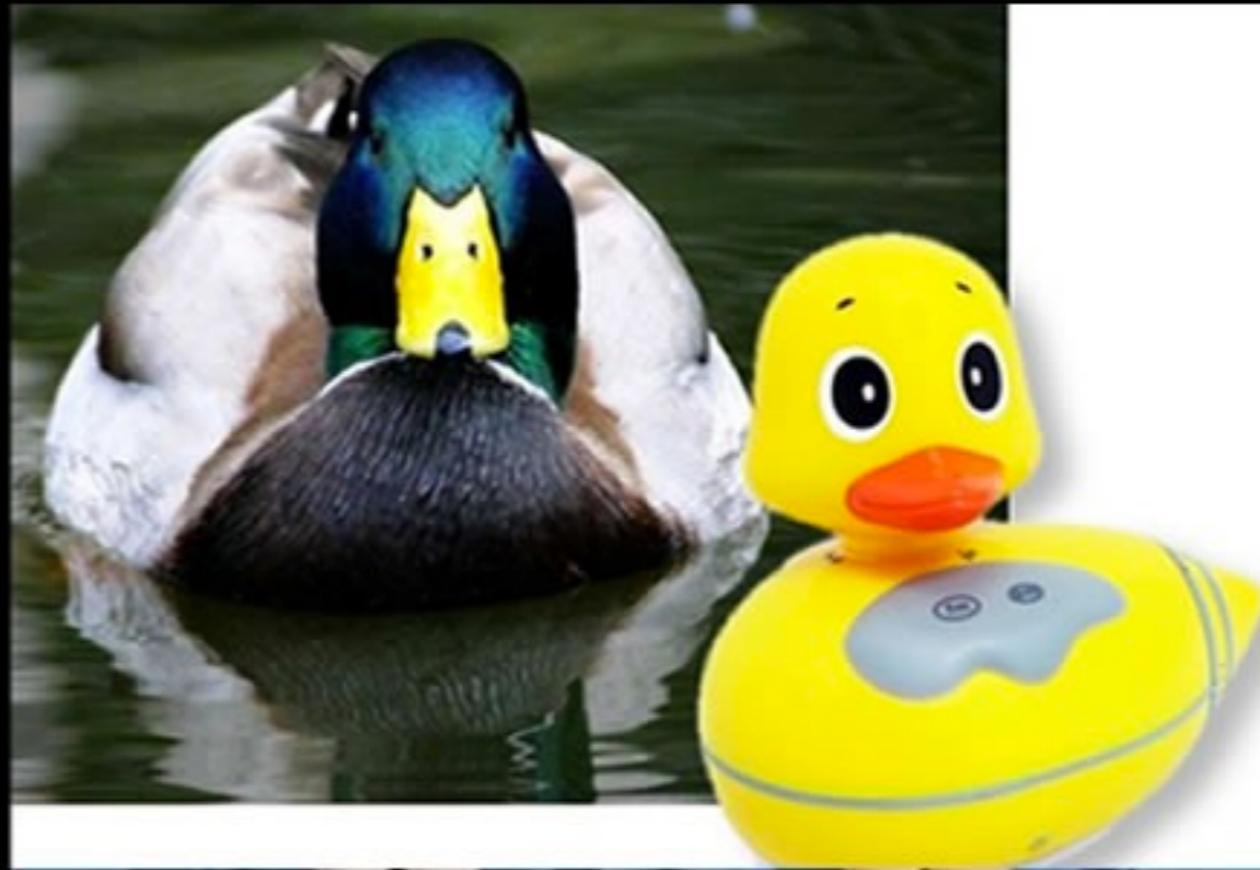
```
+draw()  
-drawCircle()  
-drawRectangle()
```



Example



Liskov Substitution Principle

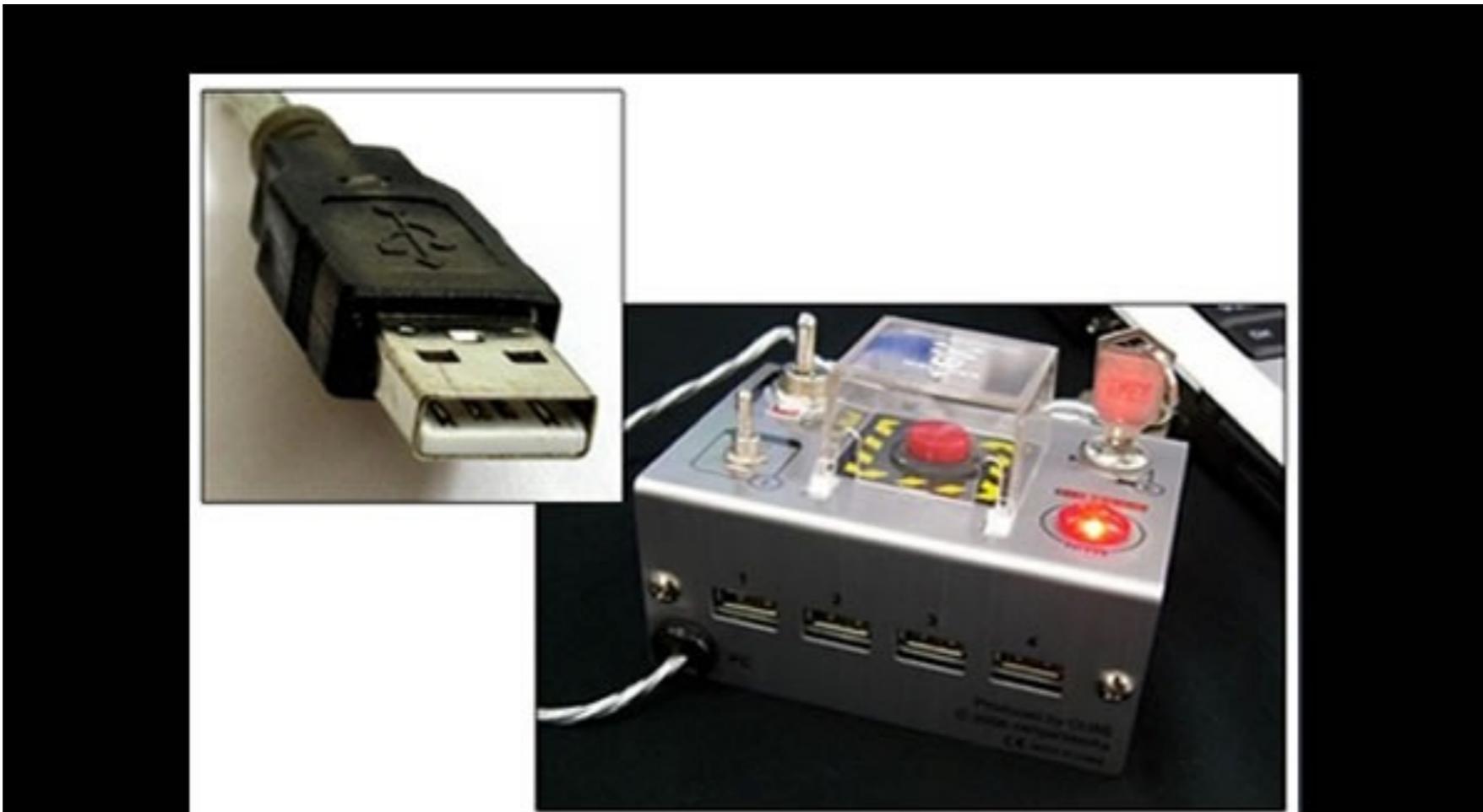


Liskov Substitution Principle

If it looks like a duck and quacks like a duck but needs batteries,
you probably have the wrong abstraction.



Interface Segregation Principle

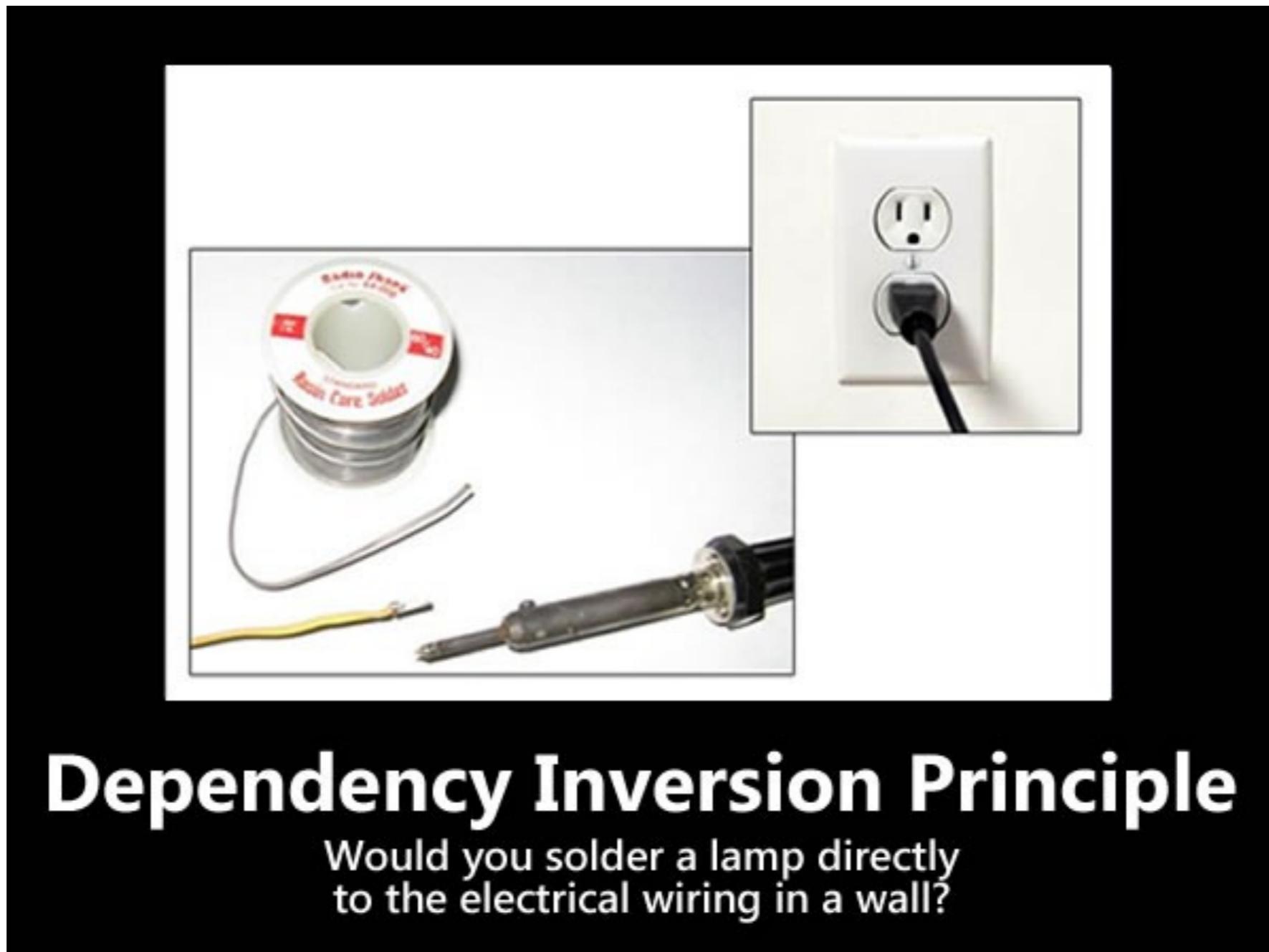


Interface Segregation Principle

You want me to plug this in *where?*



Dependency Inversion Principle



Manage your dependencies

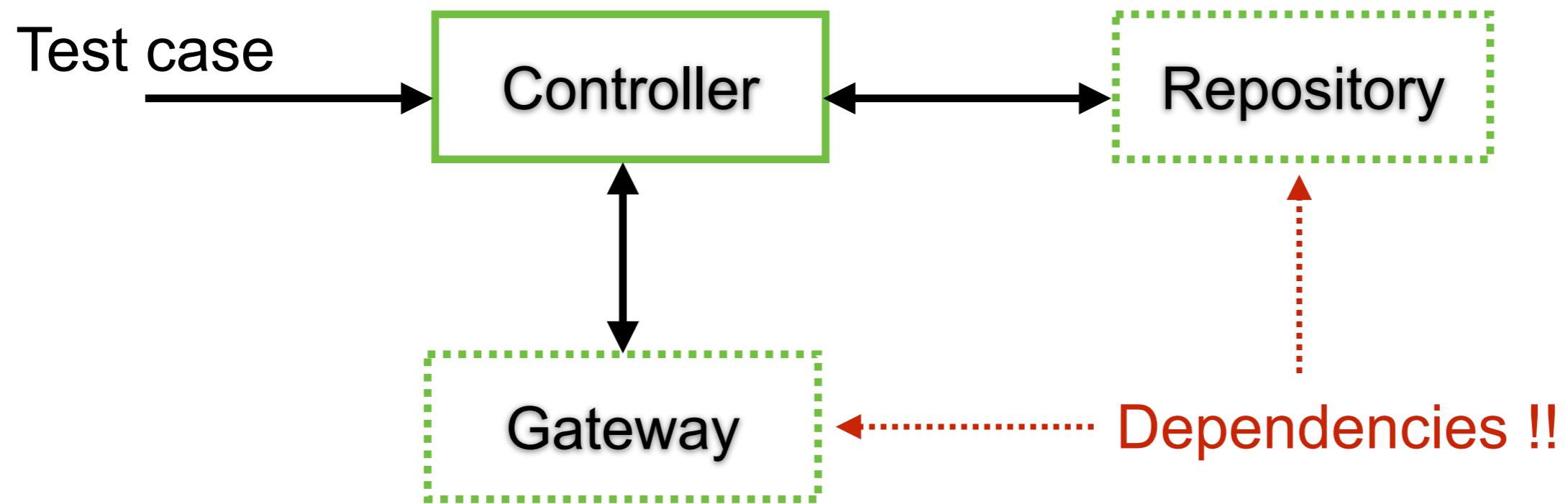


Good Unit Tests (F.I.R.S.T)

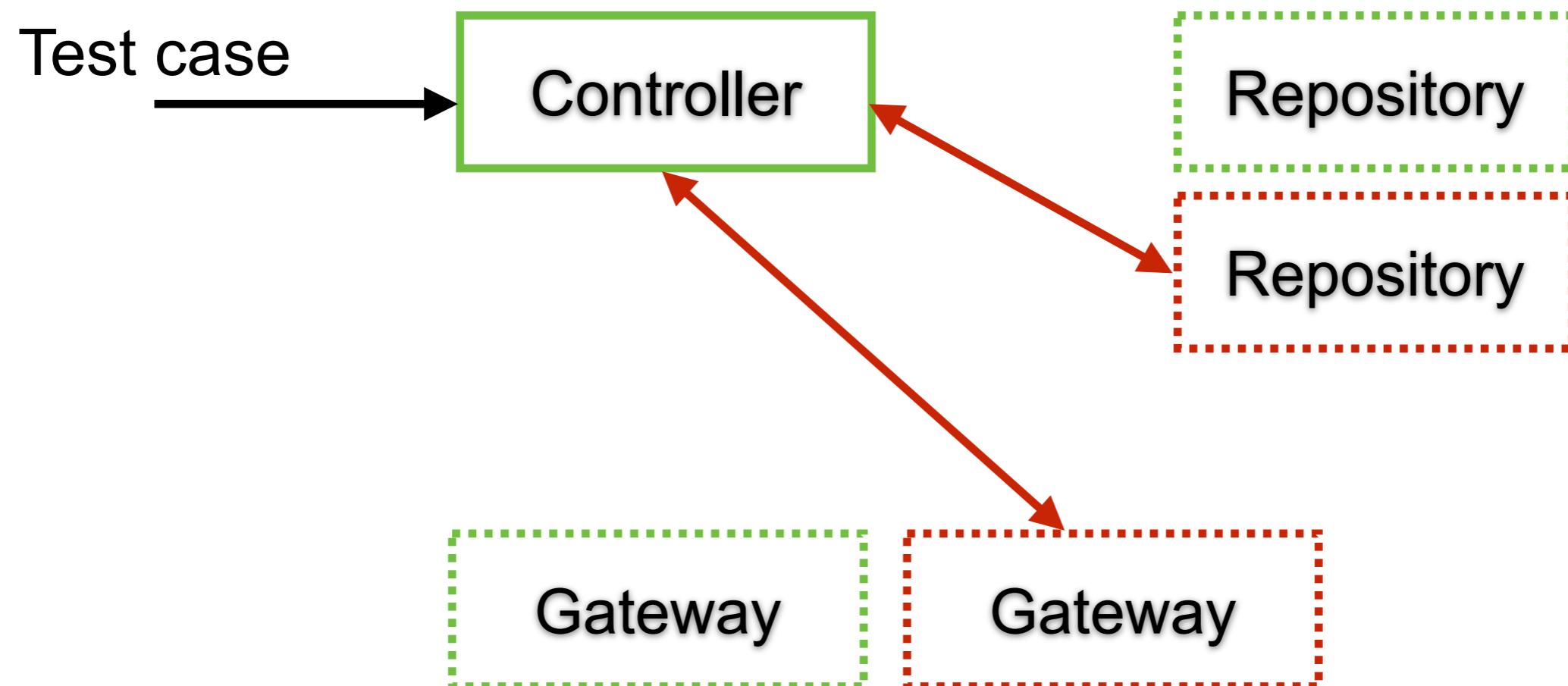
Fast
Independent/Isolate
Repeat
Self-validate
Thorough/Timely



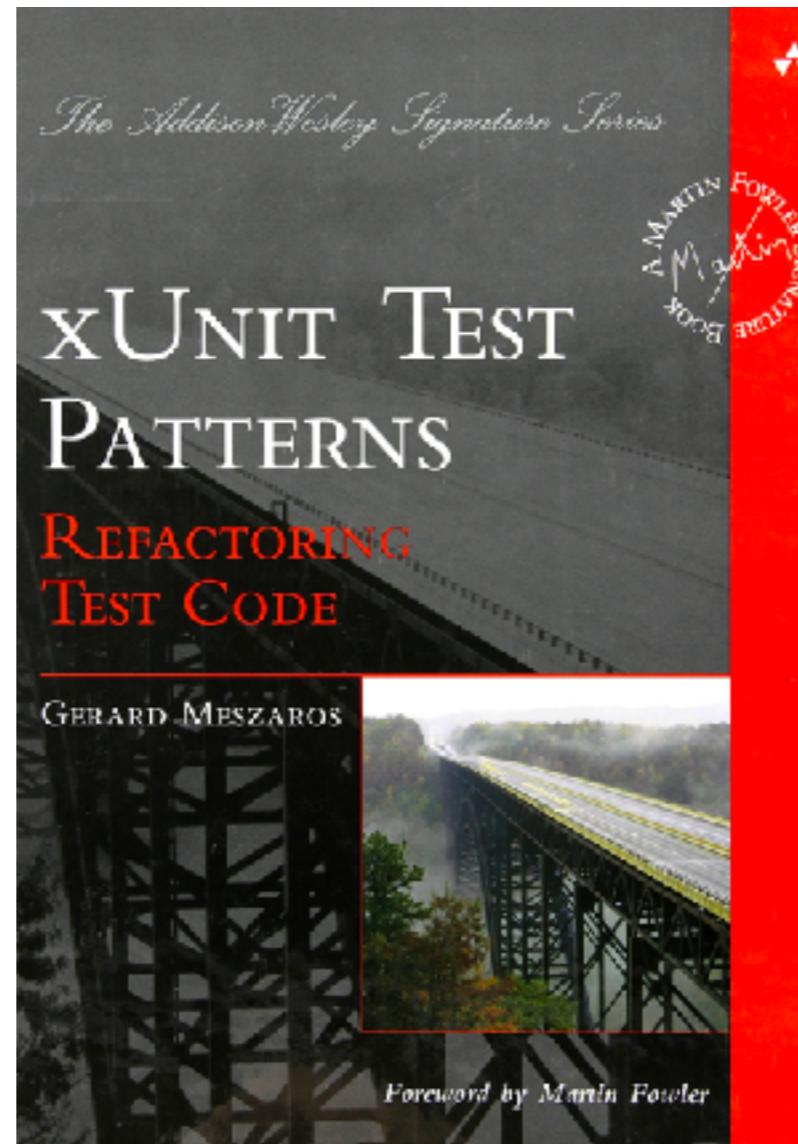
How to test Controller ?



Working with dependencies



Test double ?



<http://xunitpatterns.com>



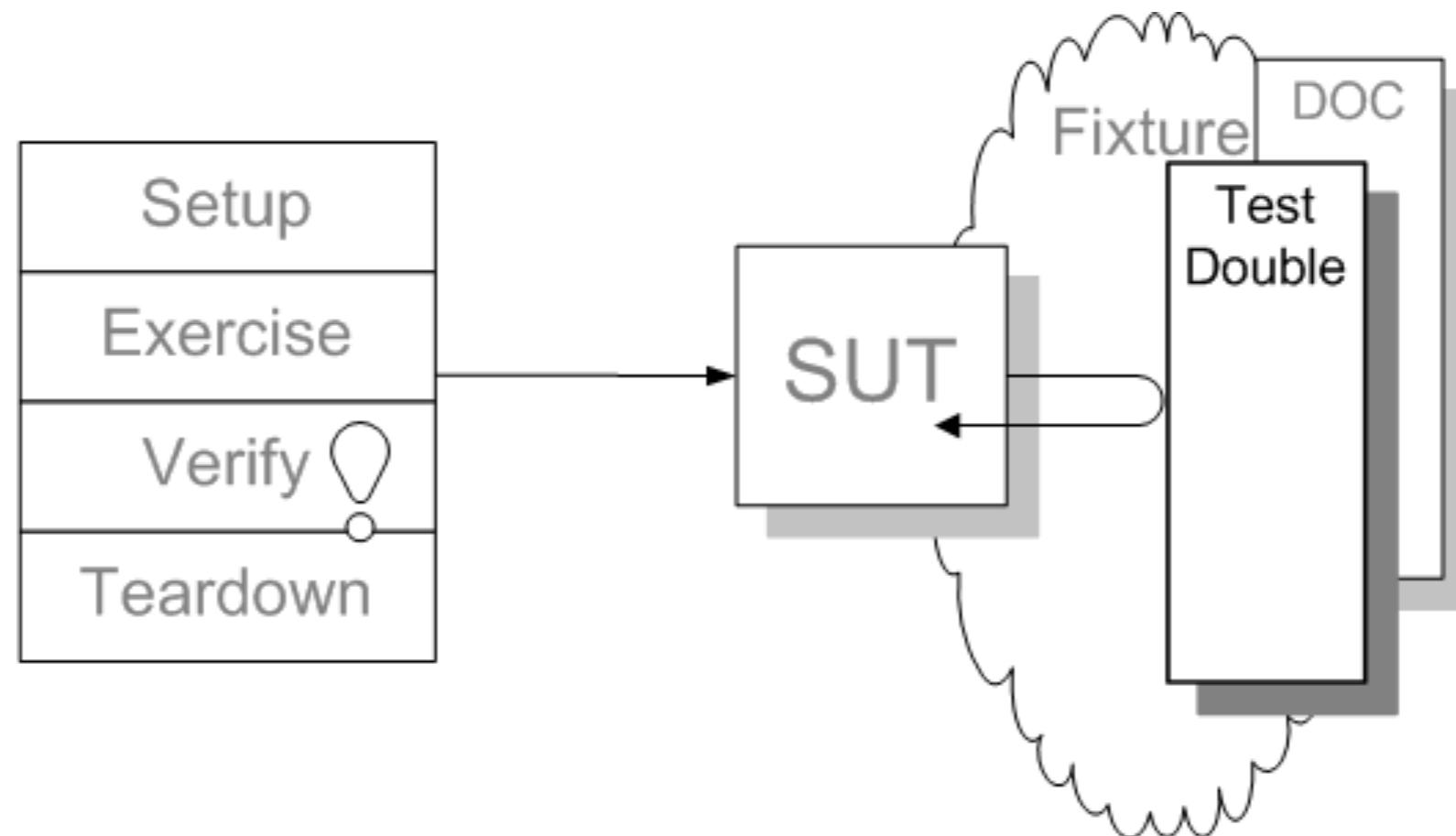
TDD with C#

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Test double ?

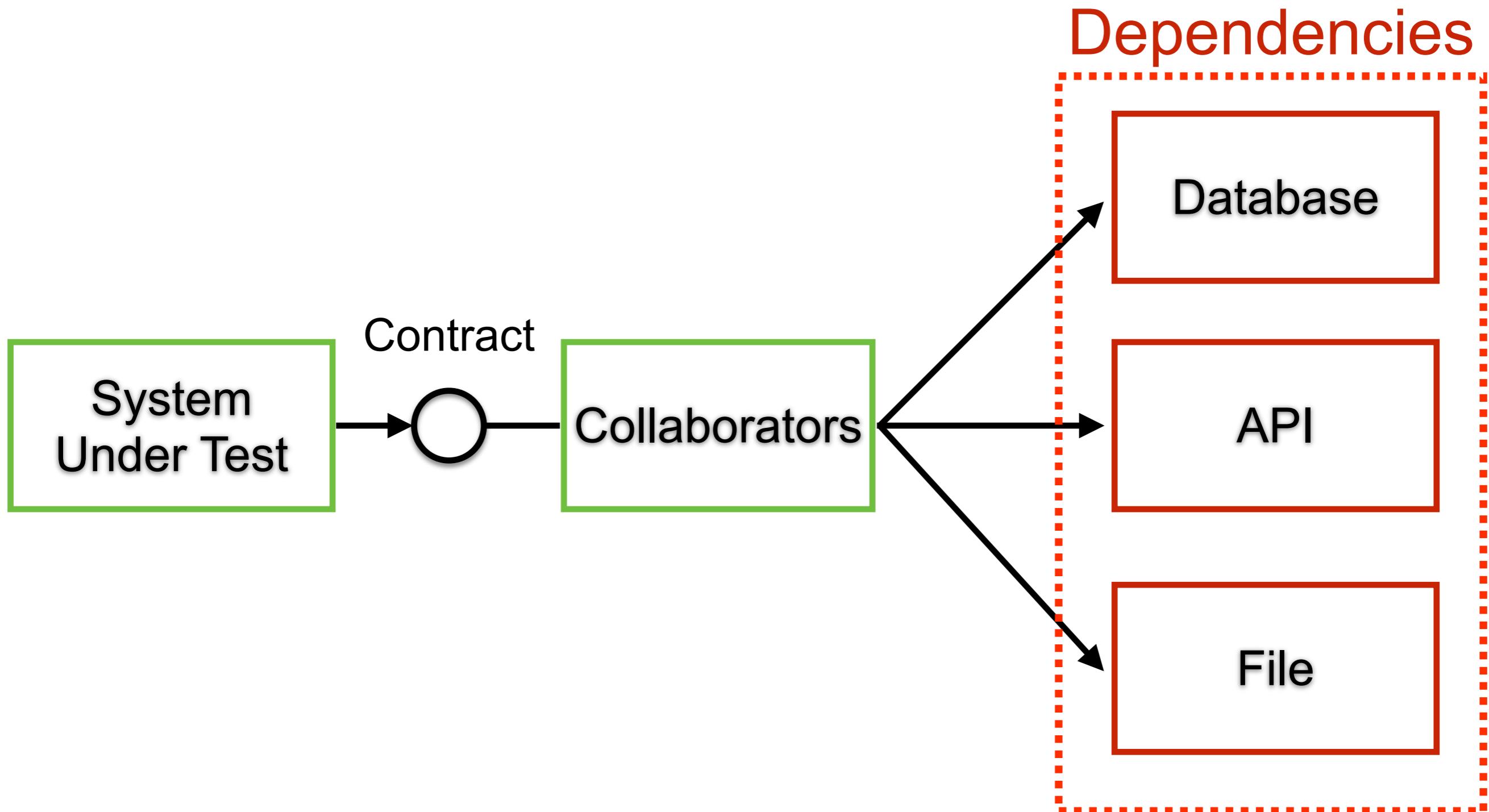
Stand-in for something that would be otherwise real
in the execution of your program



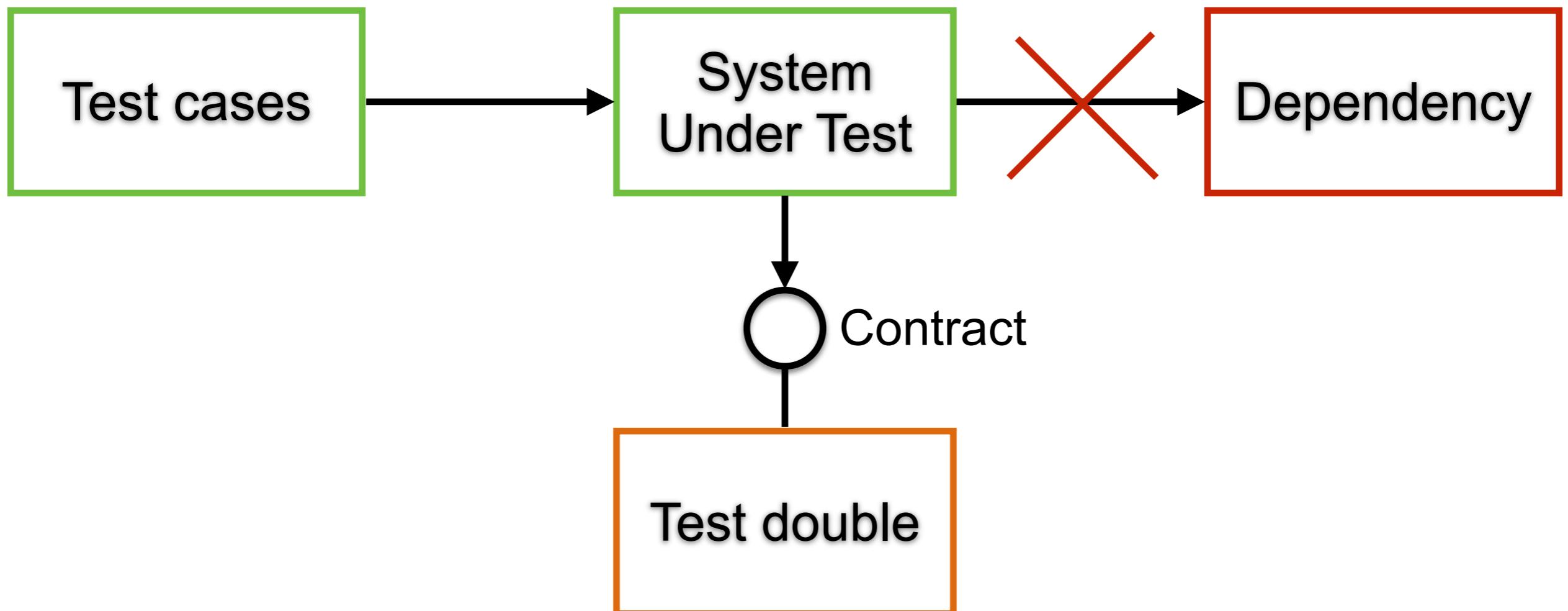
<http://xunitpatterns.com/Test%20Double.html>



Real implementation



With Test double



Types of Test double

Dummy
object

Stub

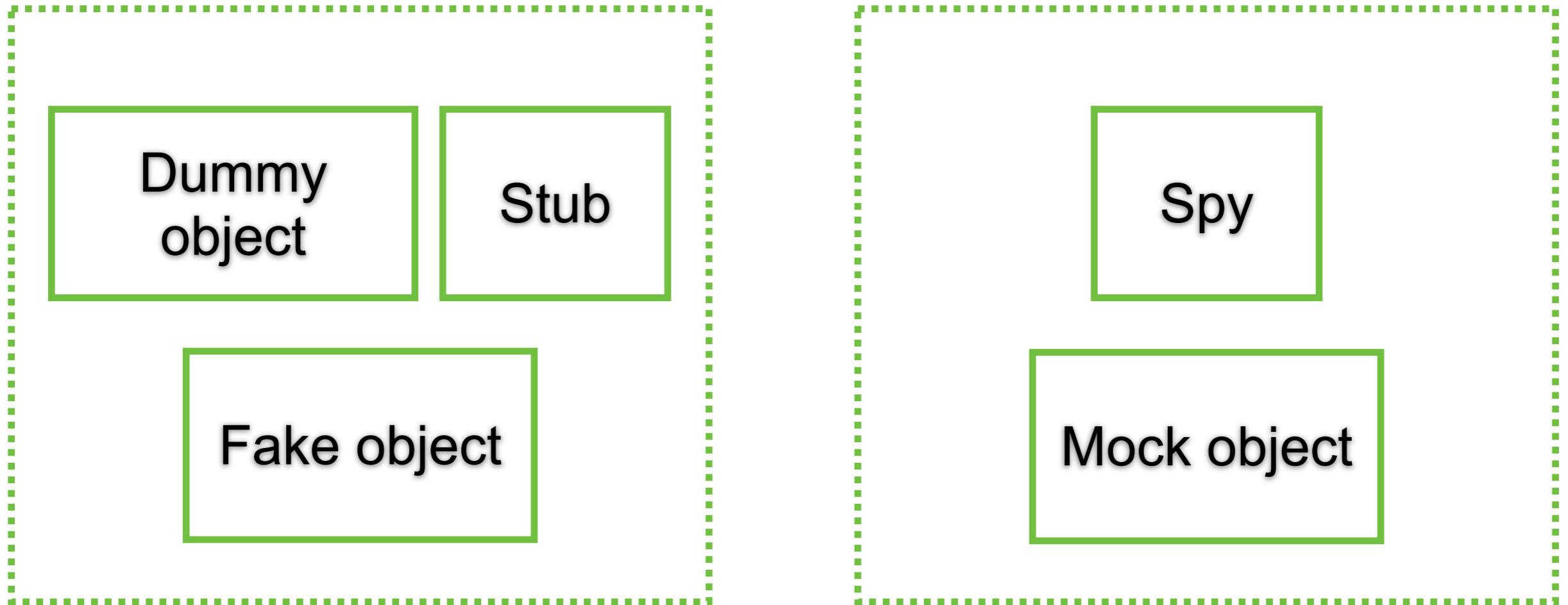
Spy

Mock object

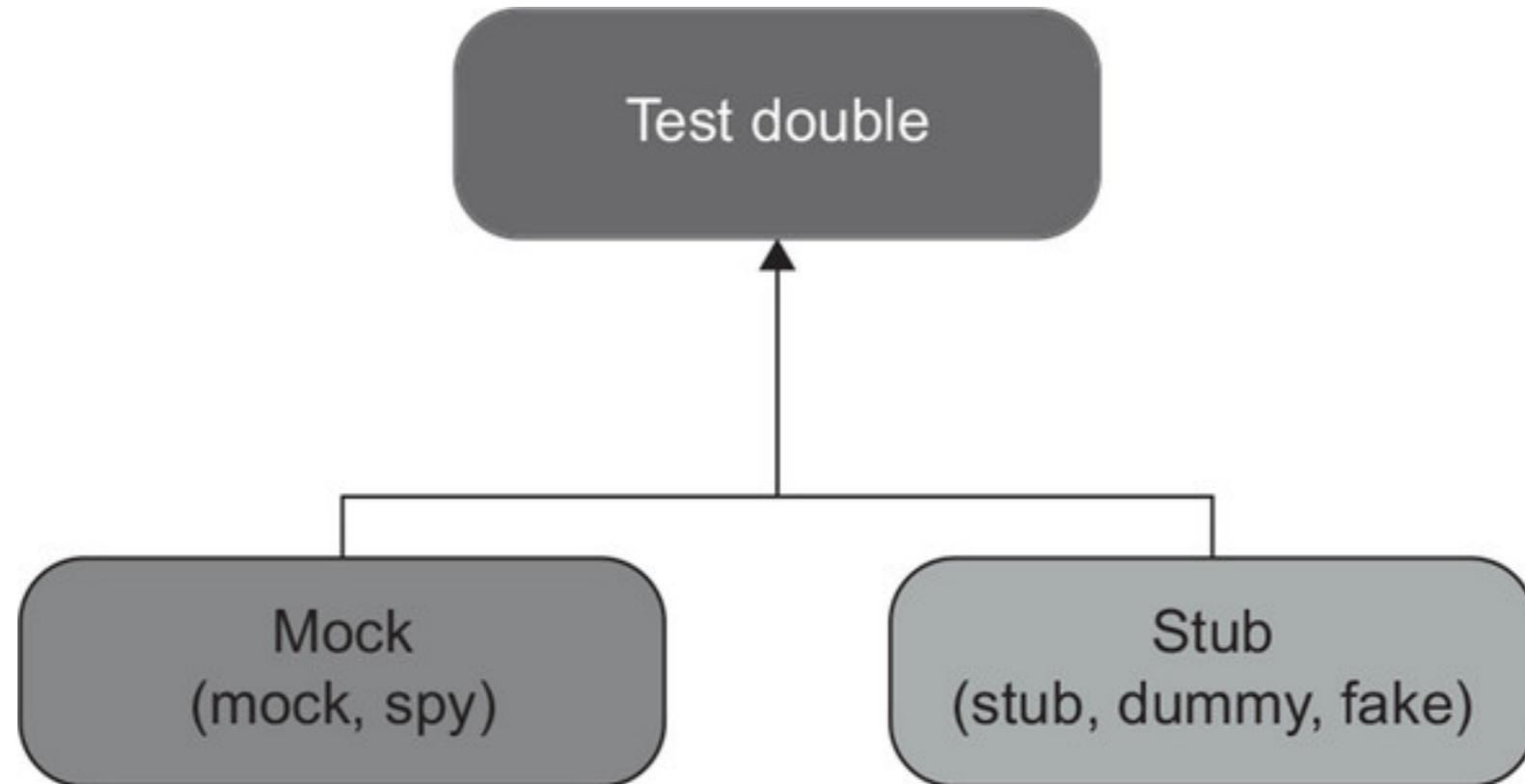
Fake object



Types of Test double

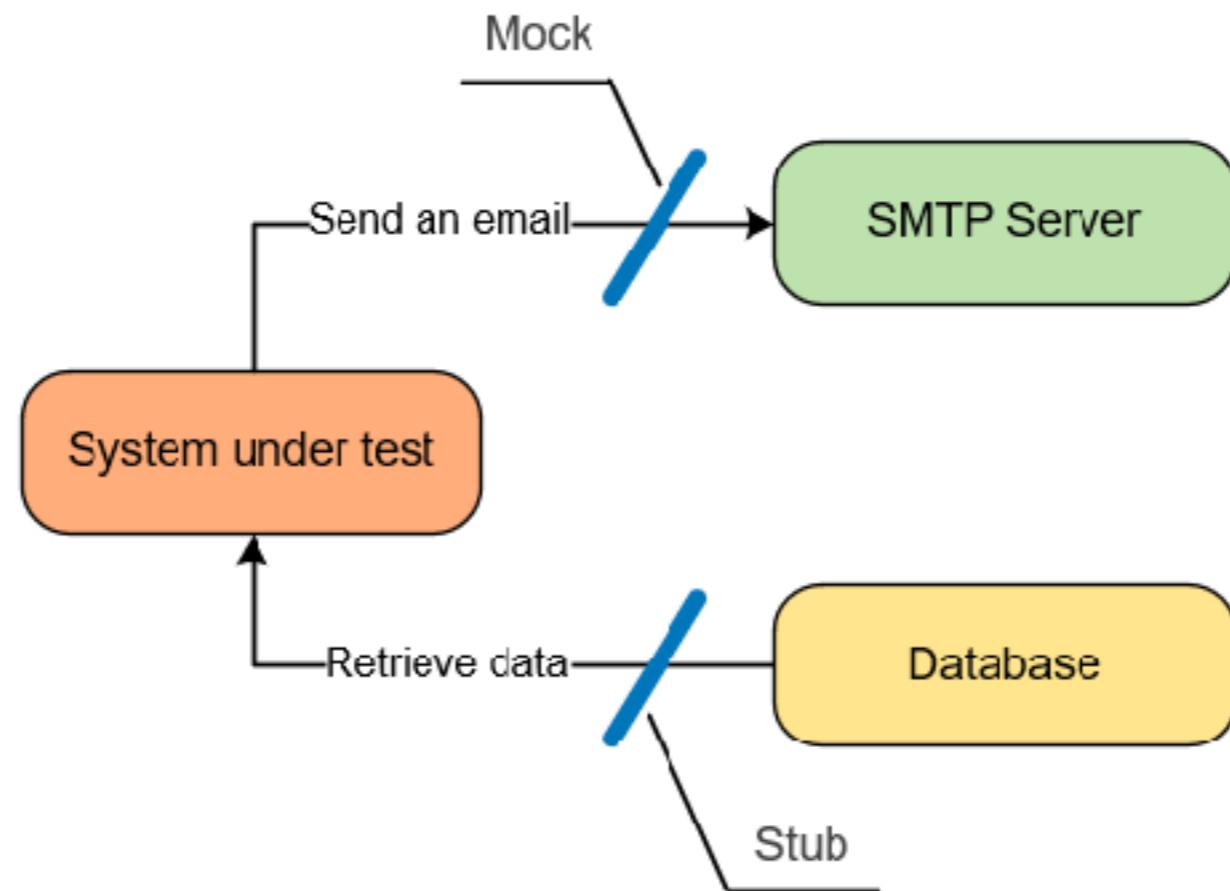


Types of Test double



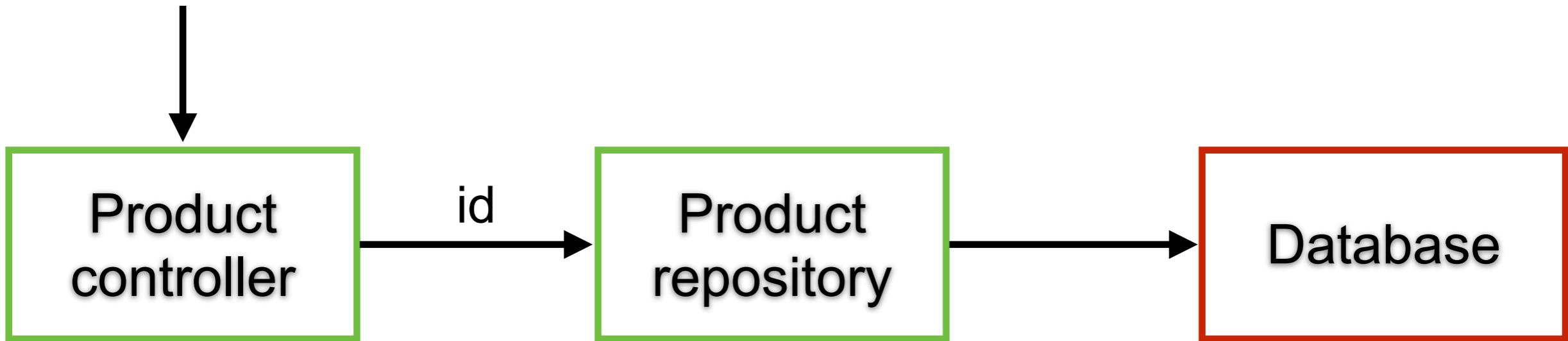
Mock vs Stub

Mock for outgoing interaction
Stub for incoming interaction



Example

Get product detail by ID



Fake

Working with implementation but take some shortcut

Not suitable for production

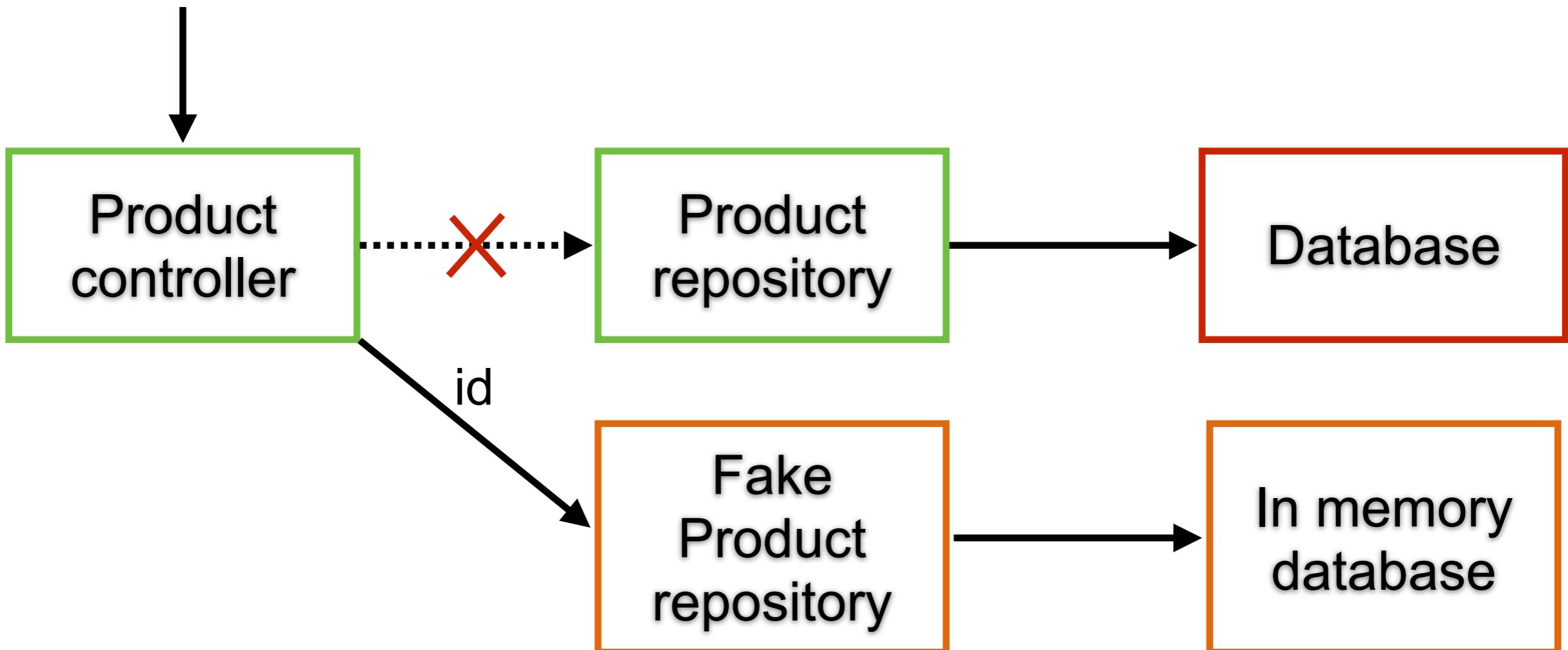
Use with read and write operations

E.g. In-memory database, Fake API server



Fake

Get product detail by ID



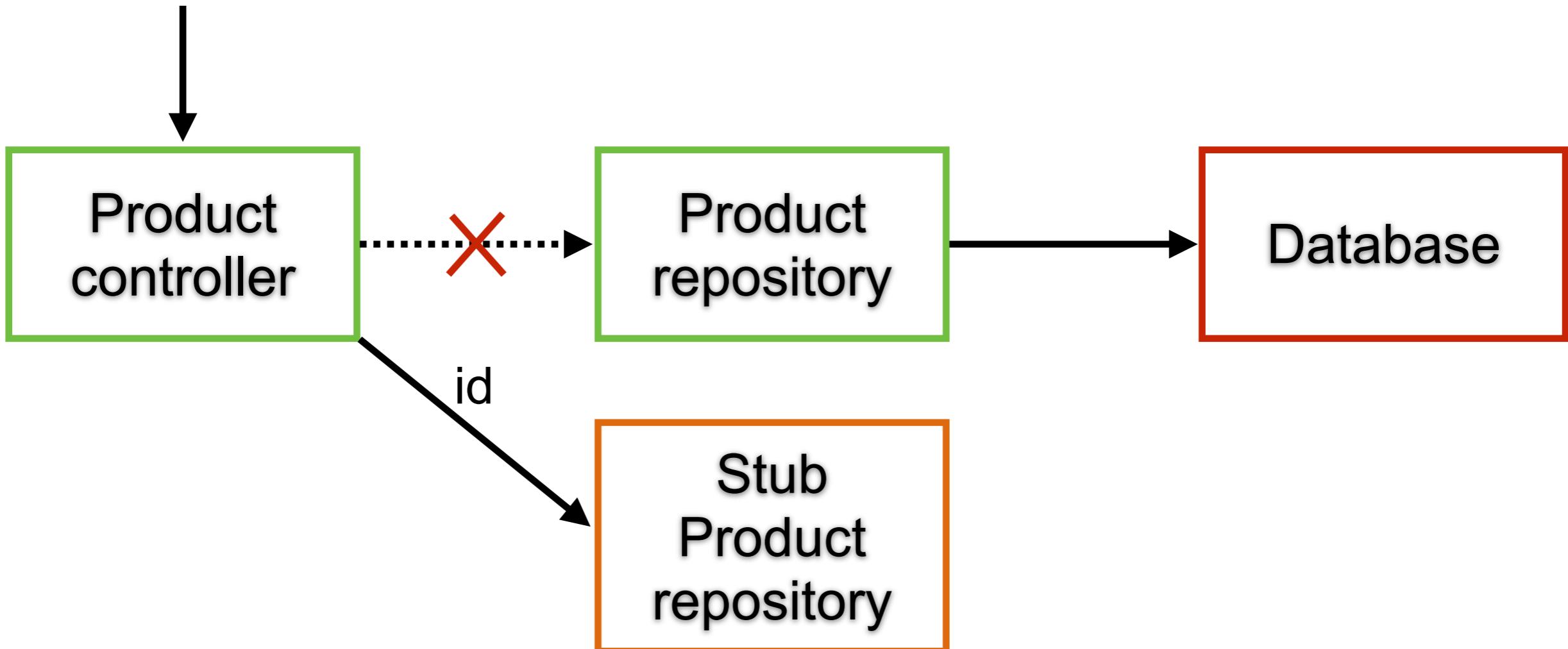
Stub

Provide answers to calls made during the test
A double with hardcoded return values



Stub

Get product detail by ID



Spy

Like stub

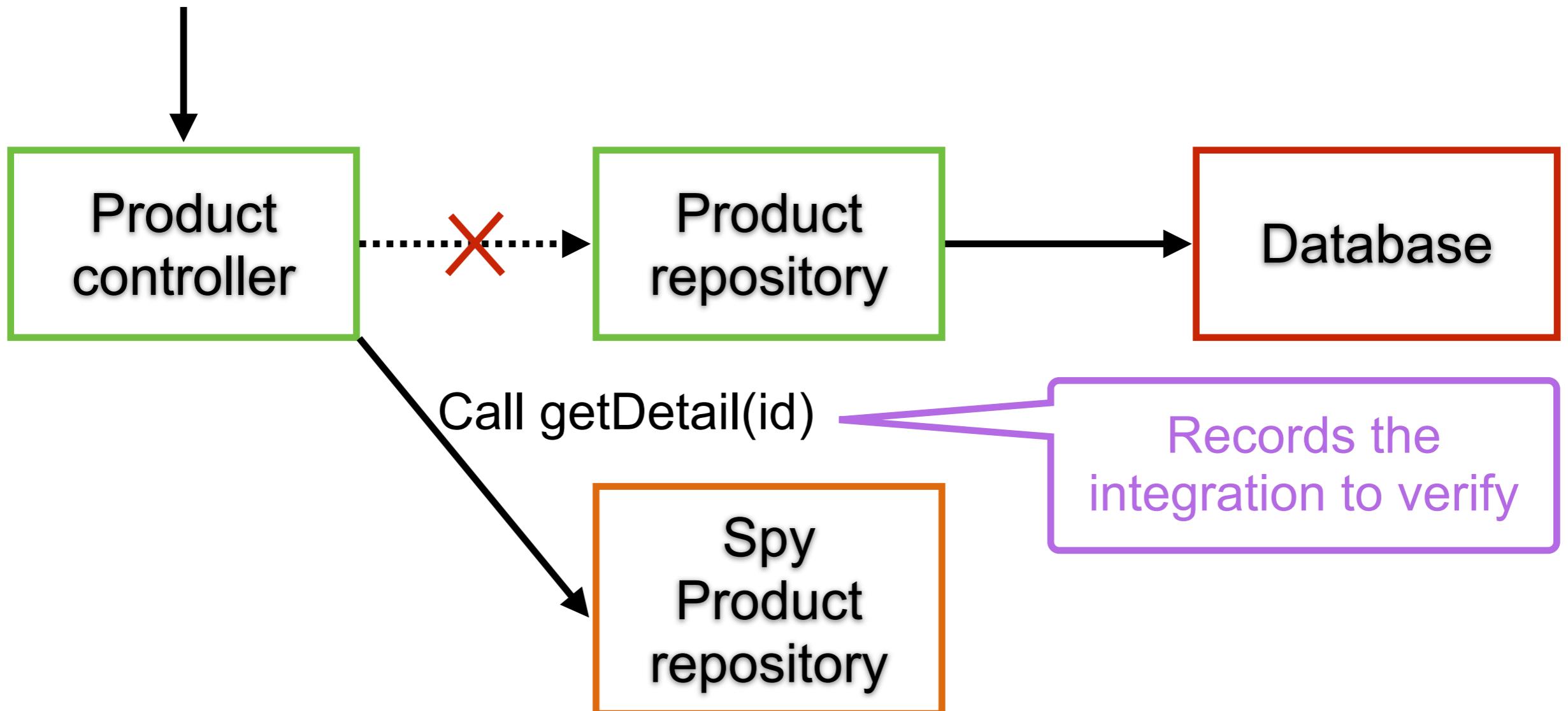
Record some information based on how its called

E.g. how many message it was sent via email service



Spy

Get product detail by ID



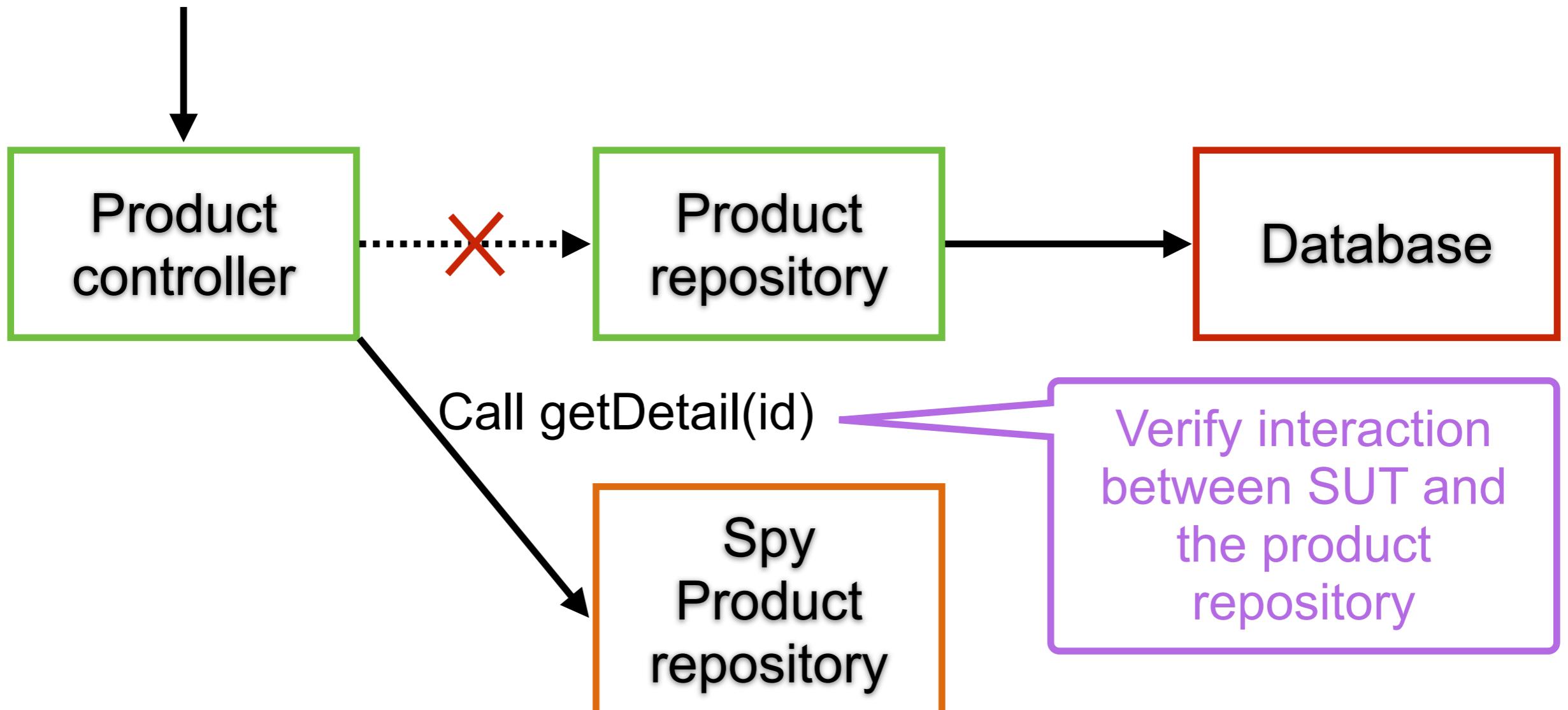
Mock object

Pre-programmed with expectations with spec
Mock object can throw an exception if receive a call
that don't expect



Mock object

Get product detail by ID



Dependency Injection

Constructor injection

Setter injection

Method injection

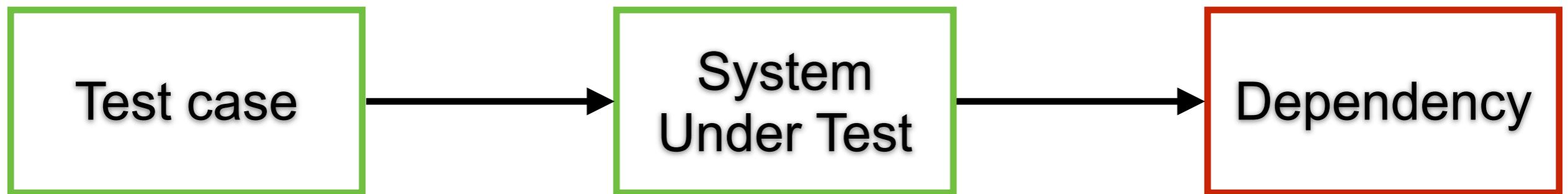


Dummy object

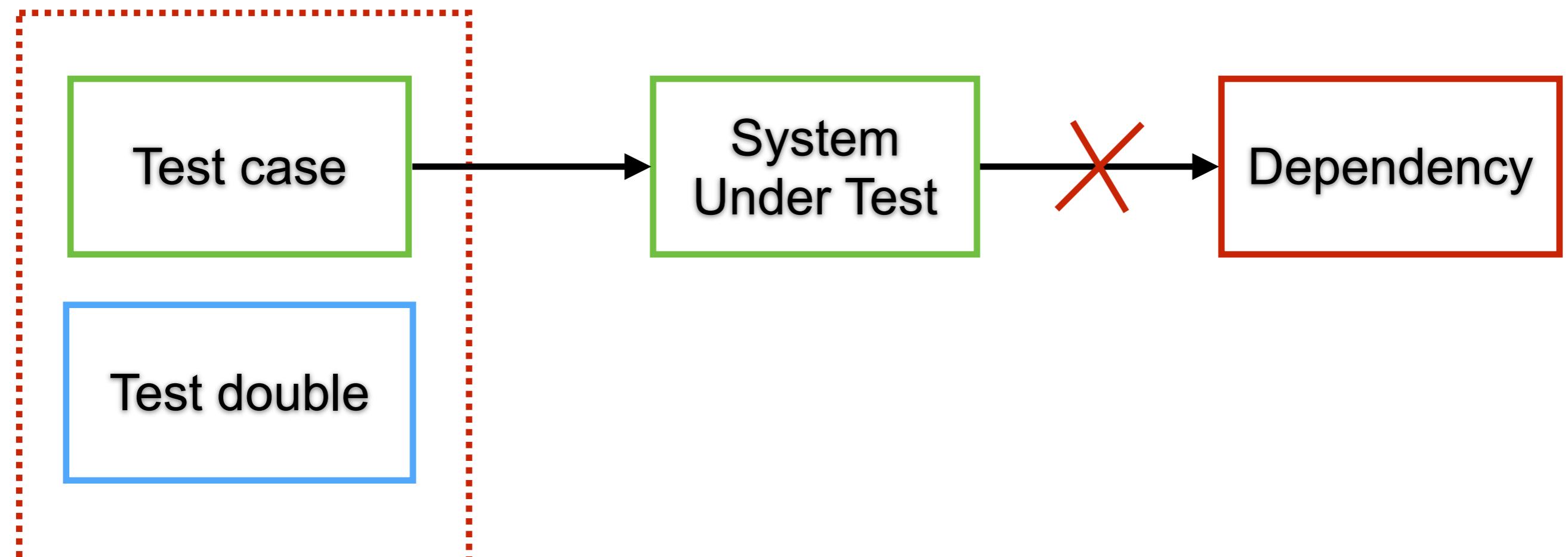
Passed around but never actually used
Used to fill parameter lists



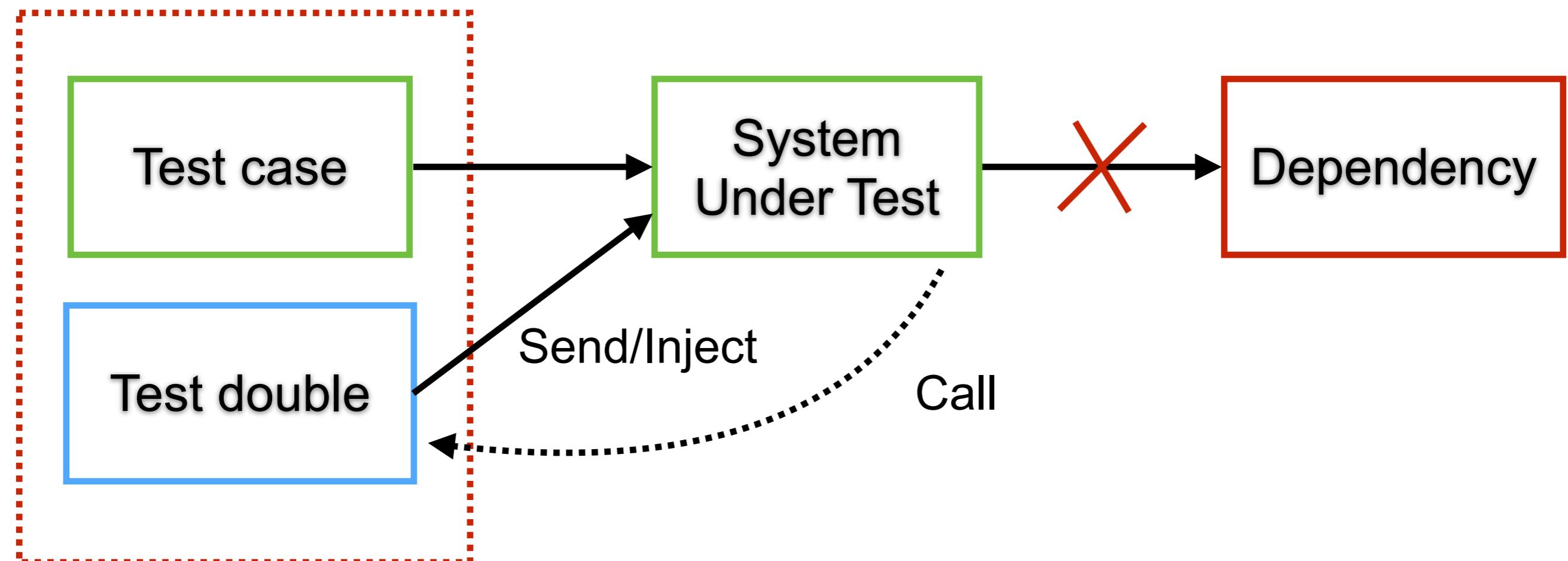
Test double ?



Create test double



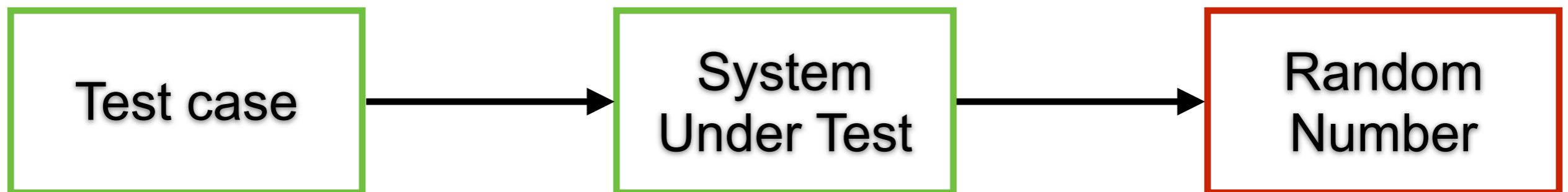
Send/inject test double to SUT



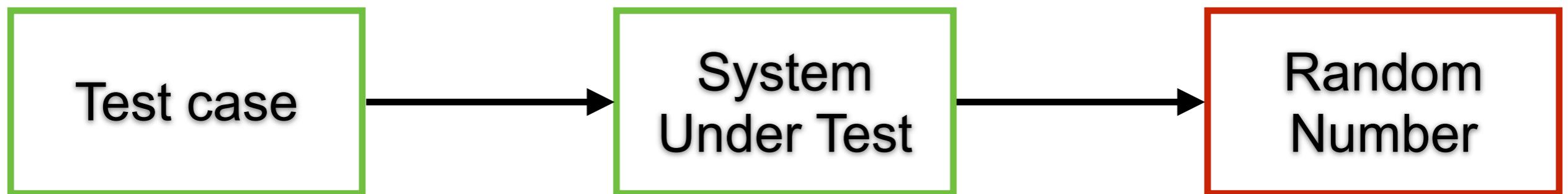
Workshop



Workshop



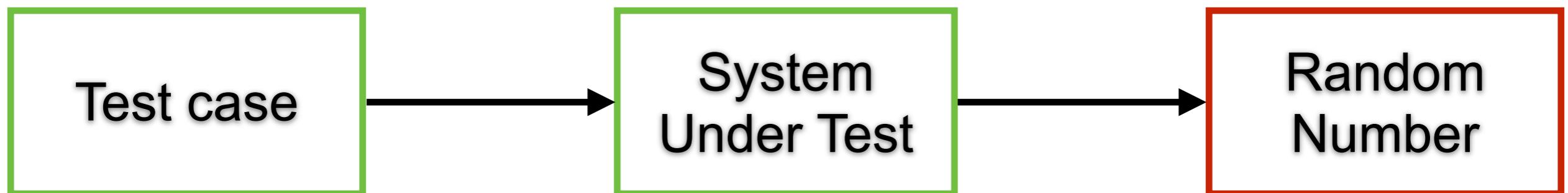
Workshop



Test random number = 5 ?



Workshop



Test random number must called 1 time ?



Start with Test !!

[Fact]

```
public void TestWithRandom5()
{
    // Arrange
    GenerateNumber g = new GenerateNumber();
    // Act
    string actualResult = g.getResult();
    // Assert
    Assert.Equal("No5", actualResult);
}
```

```
class GenerateNumber
{
    string getResult()
    {
        Random random = new Random();
        int number = random.Next(10);
        return "No" + number;
    }
}
```

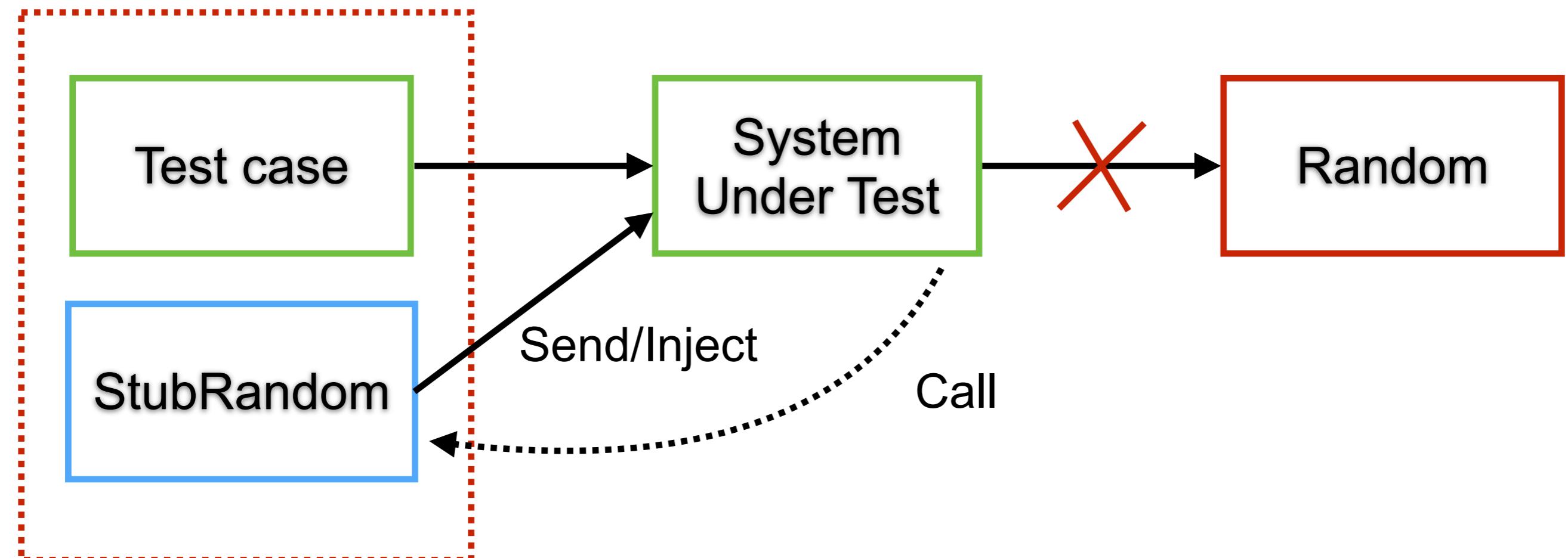


Loose coupling between classes

Override by method
Interface



Override by method



Override by method

[Fact]

```
public void TestWithRandom5WithTestDouble()
{
    // Arrange
    Random random = new StubRandom();
    GenerateNumber g = new GenerateNumber(random);
    // Act
    string actualResult = g.getResult();
    // Assert
    Assert.Equal("No5", actualResult);
}
```

```
class StubRandom: Random
{
    public override int Next(int maxValue)
    {
        return 5;
    }
}
```



Using Interface

[Fact]

```
public void TestWithRandom5WithTestDouble()
{
    // Arrange
    MyRandom random = new StubRandom();

    GenerateNumber g = new GenerateNumber(random);
    // Act
    string actualResult = g.getResult();
    // Assert
    Assert.Equal("No5", actualResult);
}
```

```
interface MyRandom
{
    int Next(int maxValue);
}
```

implement

```
class StubRandom: MyRandom
{
    public int Next(int maxValue)
    {
        return 5;
    }
}
```



Working with Test Double



<https://github.com/moq/moq>



Stub with Moq

```
using Moq;

public class UnitTest5
{
    [Fact]
    public void TestWithRandom5WithMoq()
    {
        // Arrange
        Mock<MyRandom> stub = new Mock<MyRandom>();
        stub.Setup(x => x.Next(10)).Returns(5);

        GenerateNumber g = new GenerateNumber(stub.Object);
        // Act
        string actualResult = g.getResult();
        // Assert
        Assert.Equal("No5", actualResult);
    }
}
```



Workshop with Login process

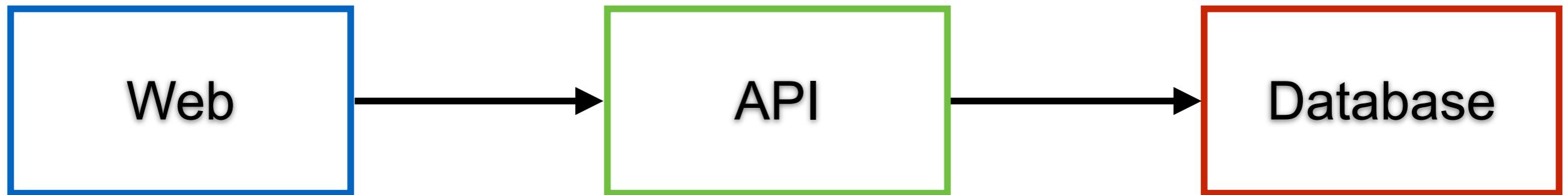


Test login

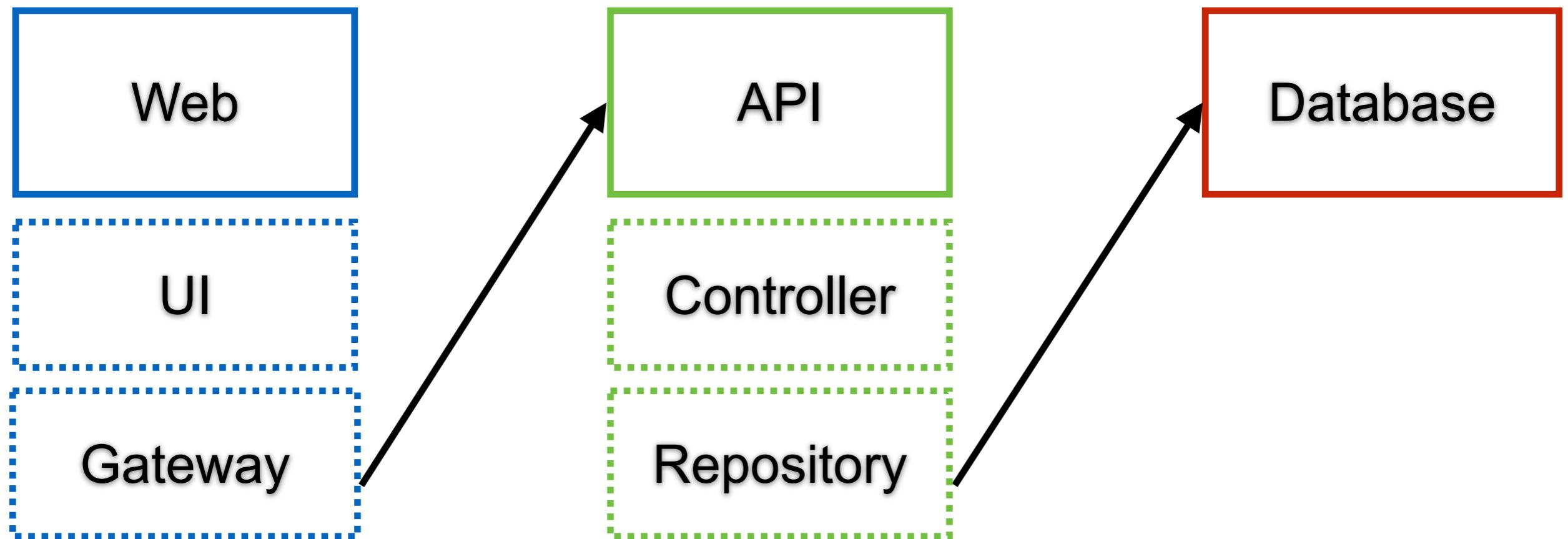
User name	Password	Expected result	Comment
Somkiat	PasswordSomKiat	Access to system as Somkiat	Valid
Som kiat	PasswordSomKiat	Error	Space in user
Somkiat	Password SomKiat	Error	Space in password
Somkiat	1234	Error	Password too short



Workshop :: Login



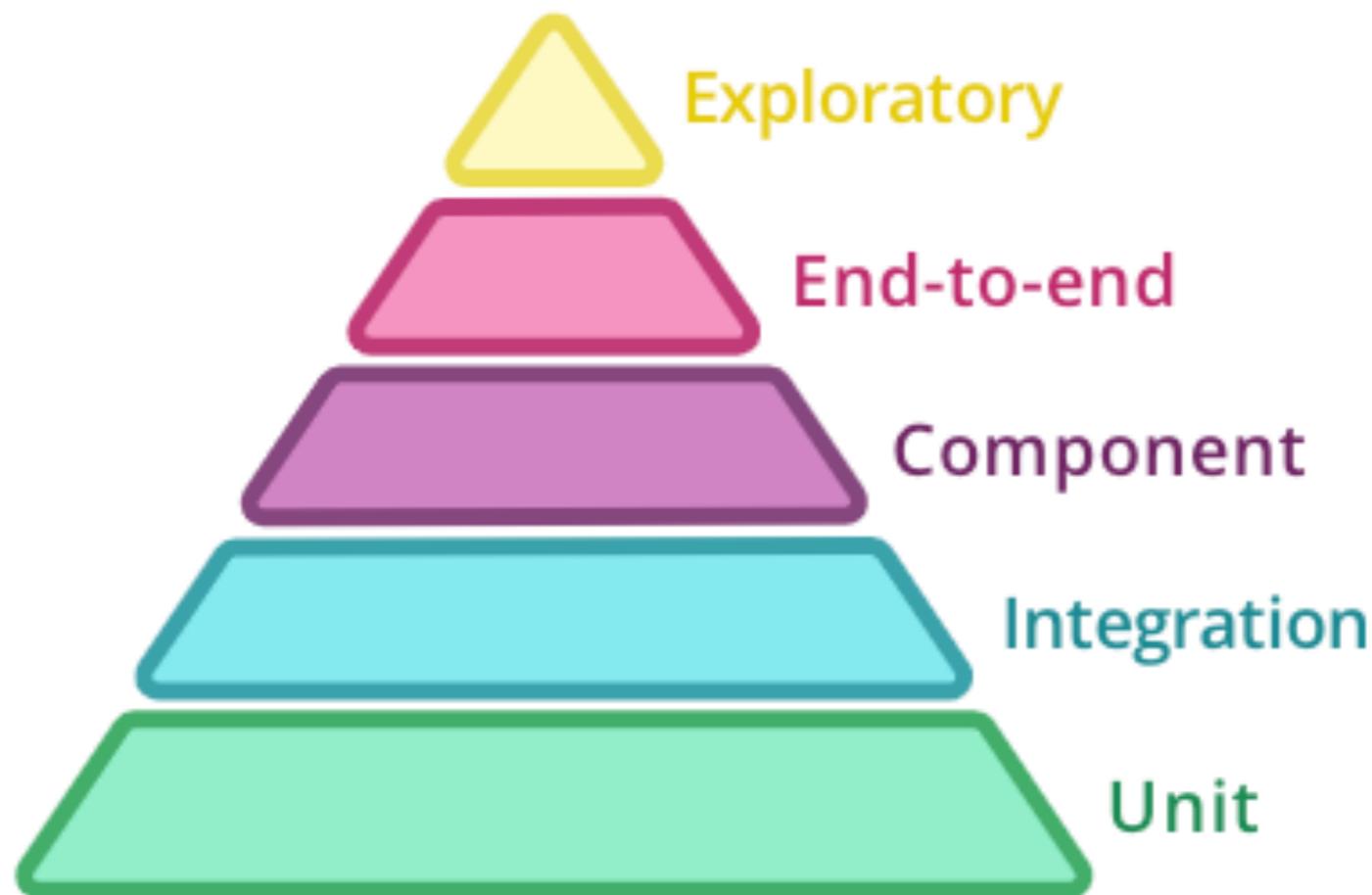
Workshop :: Login



What to test ?



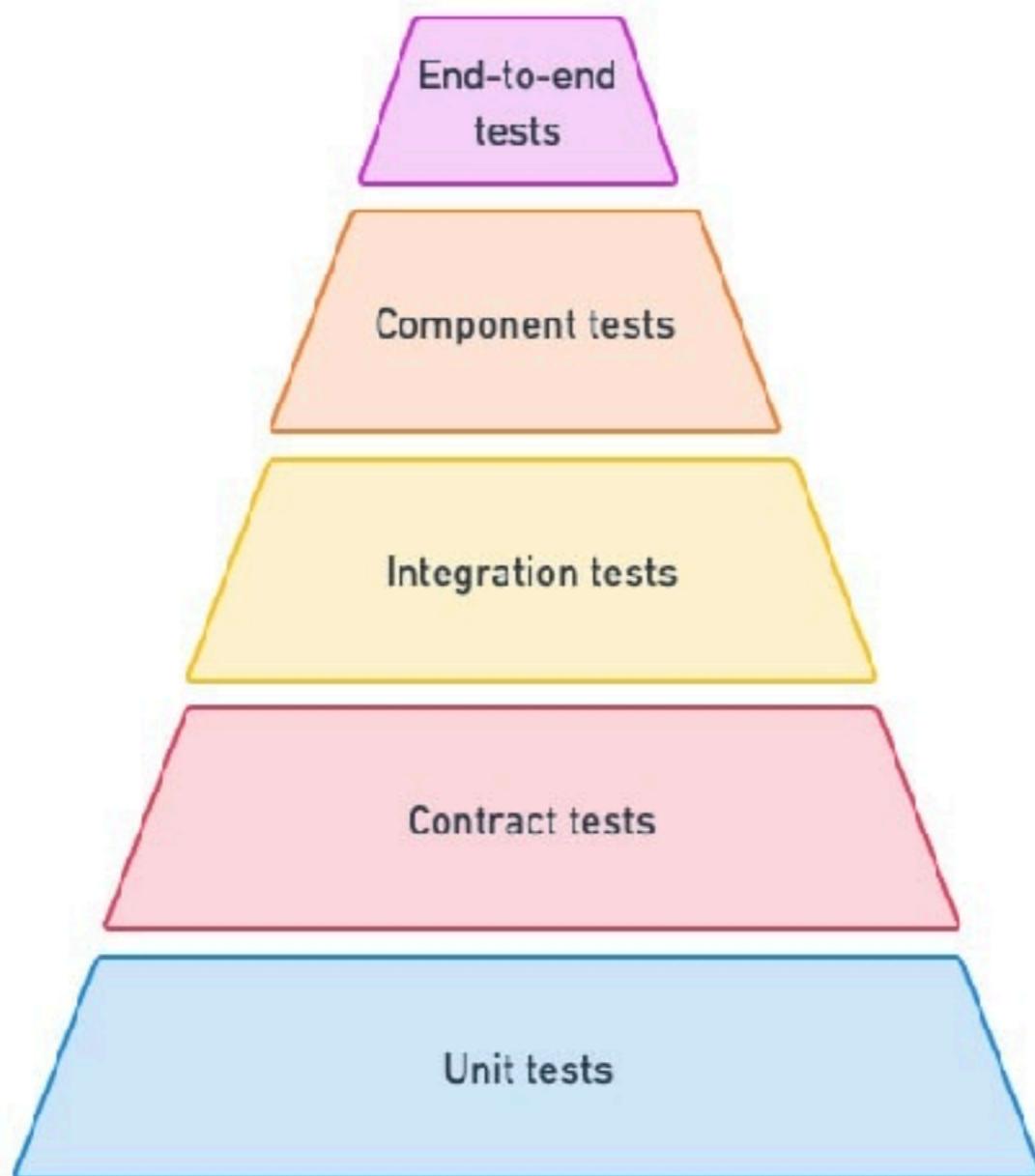
What to test ?



Testing Strategies



Testing Strategies



<https://semaphoreci.com/blog/test-microservices>



Testing Strategies

Unit test

Integration test

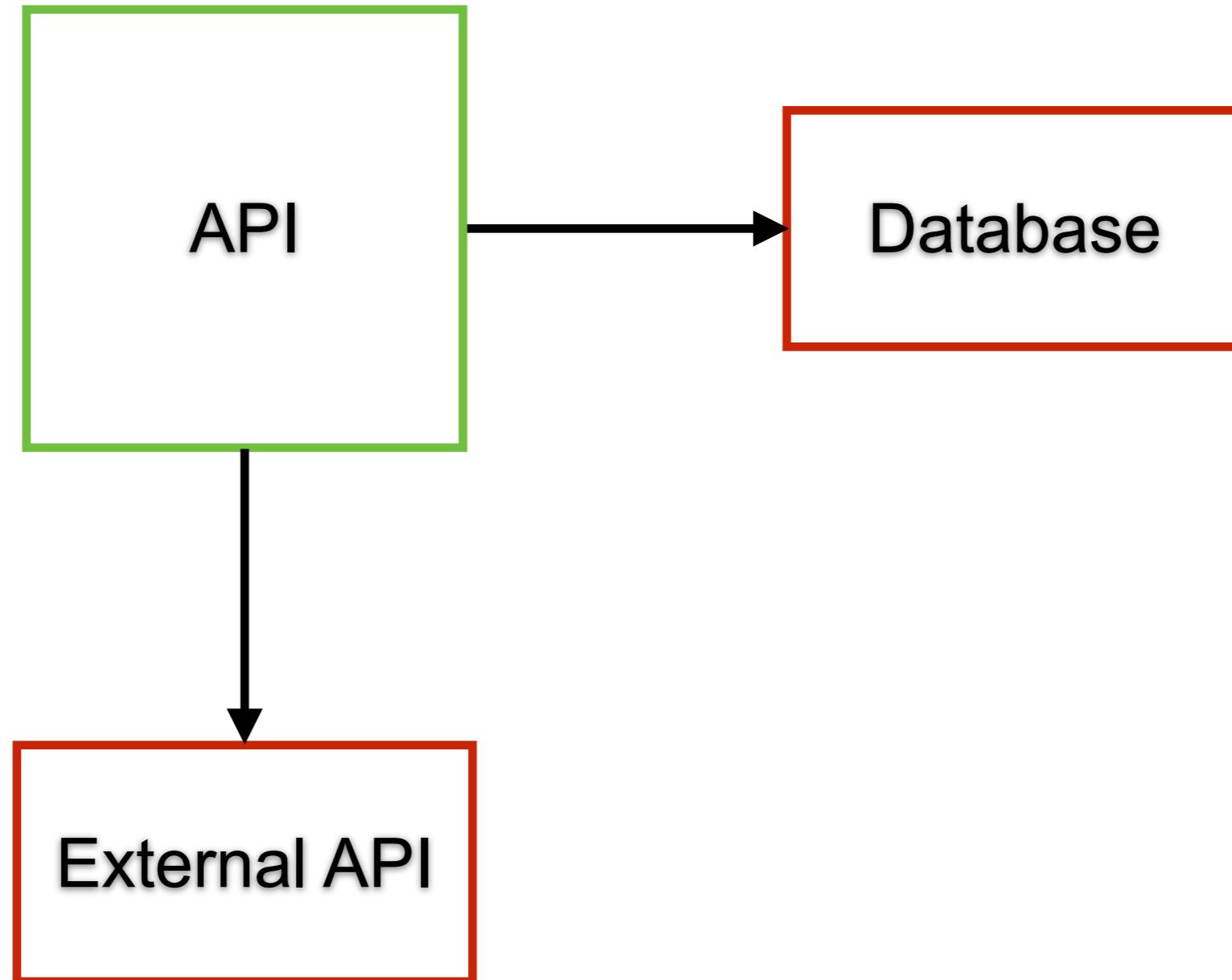
Component test

Contract test

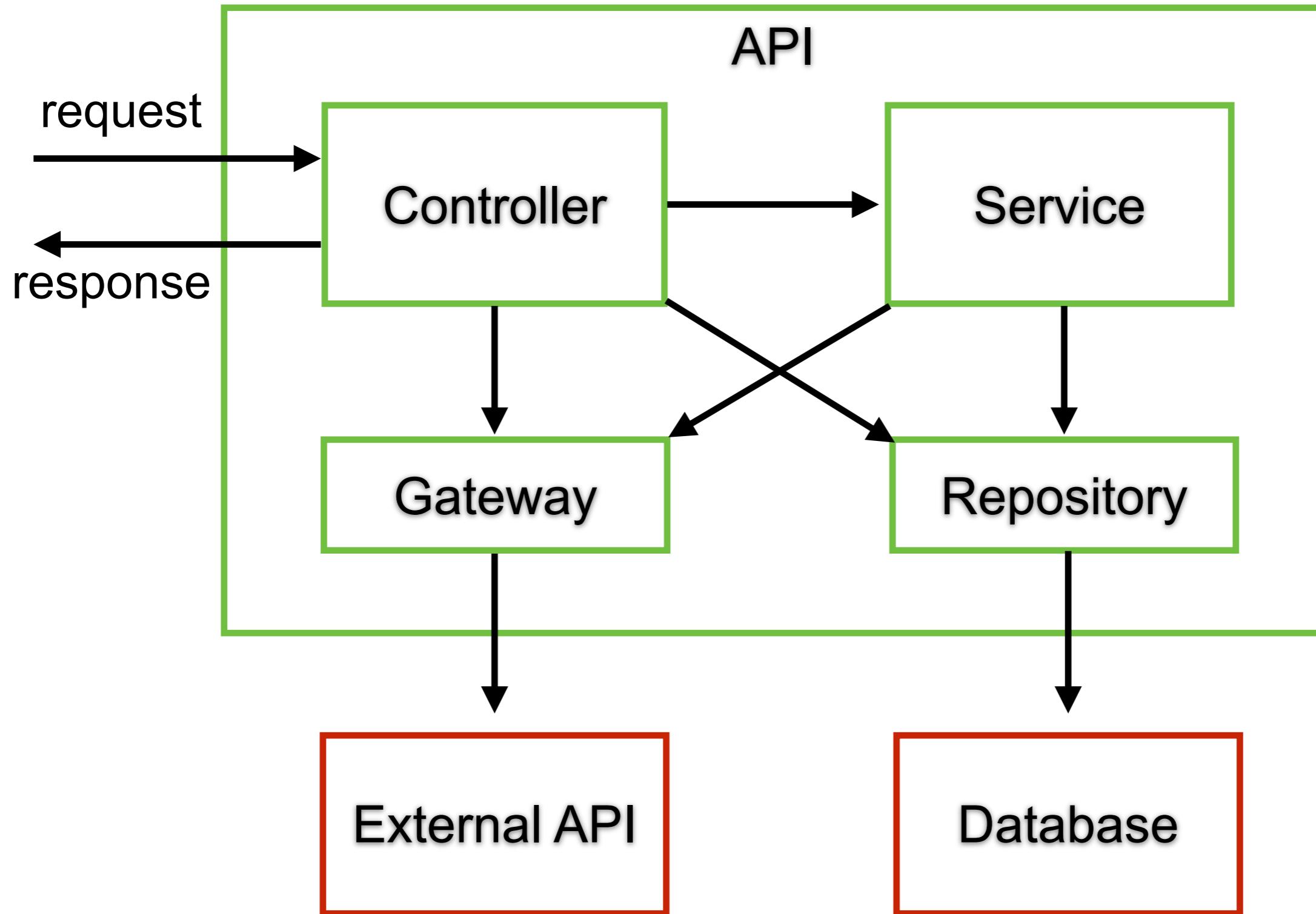
End-to-End test



Structure of your project

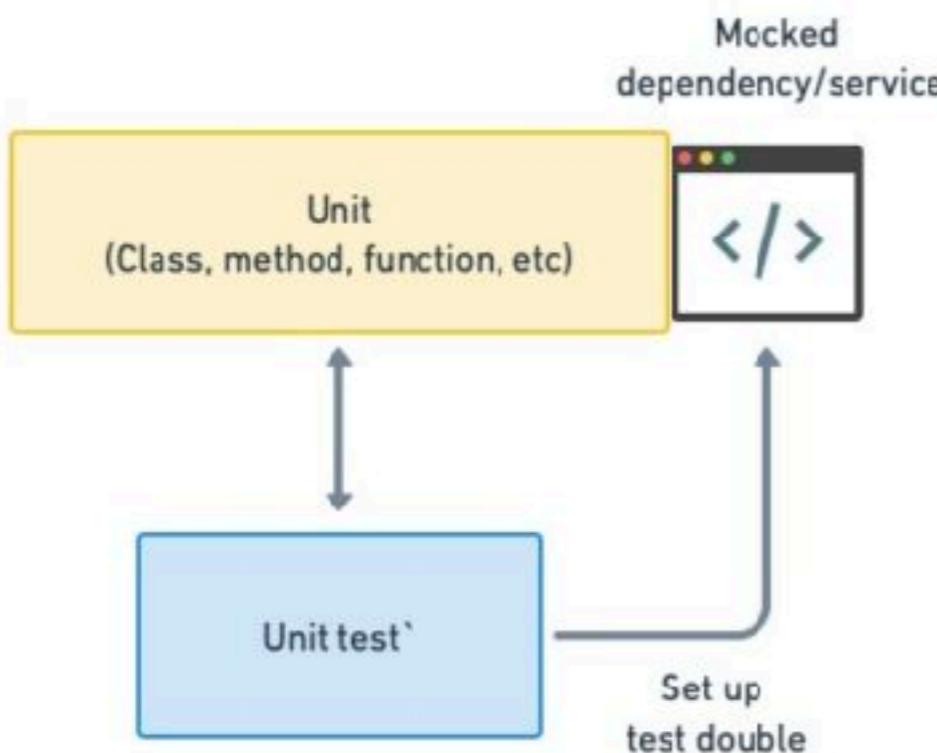


Structure of your project

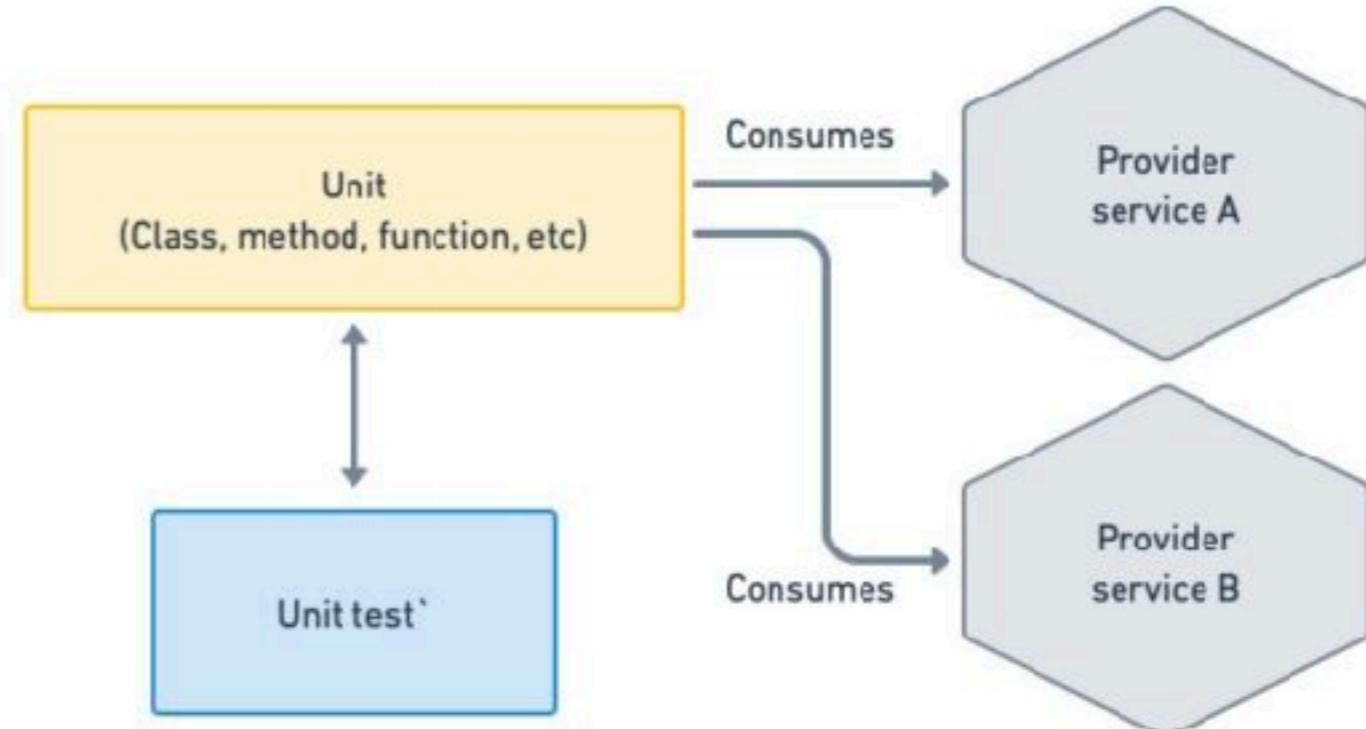


Unit test

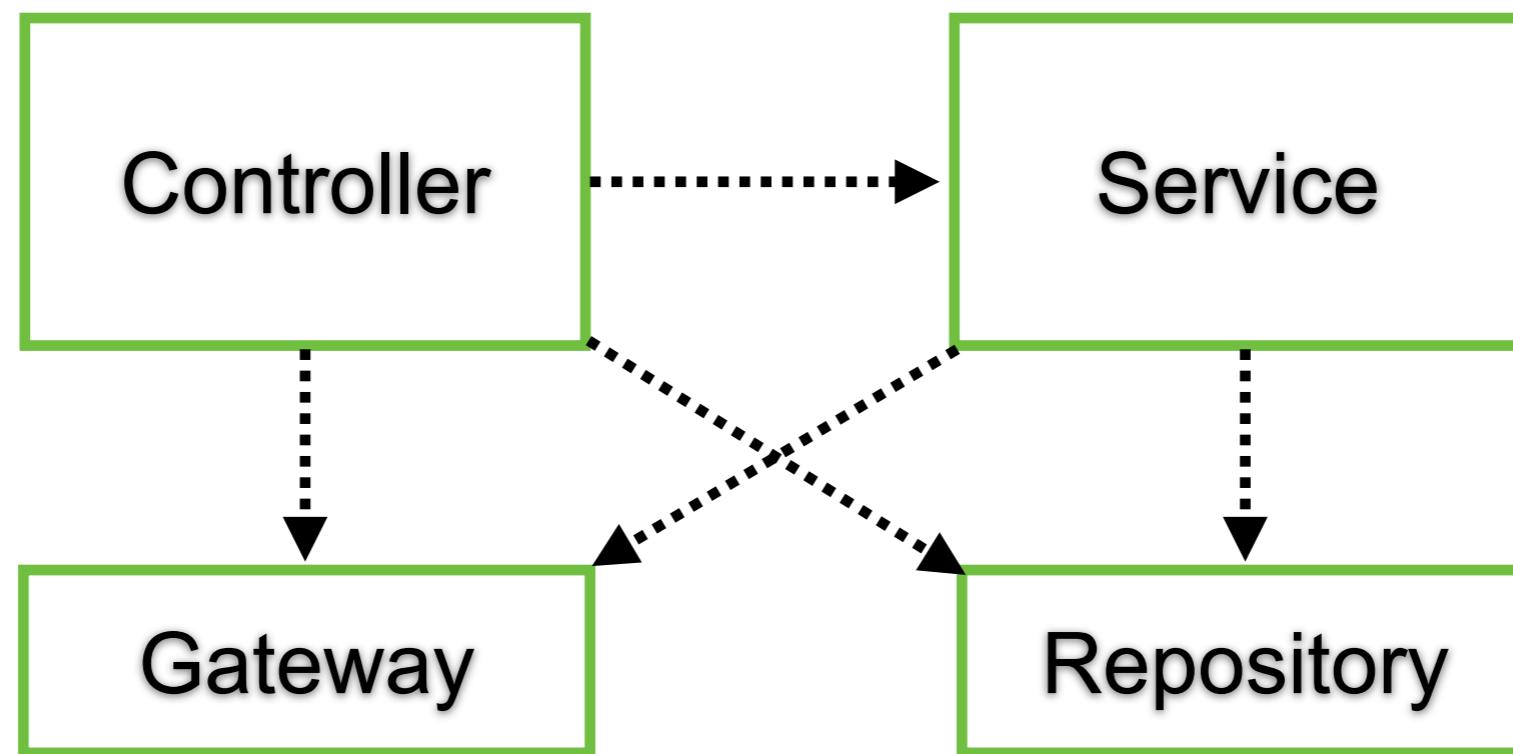
Unit test in isolation



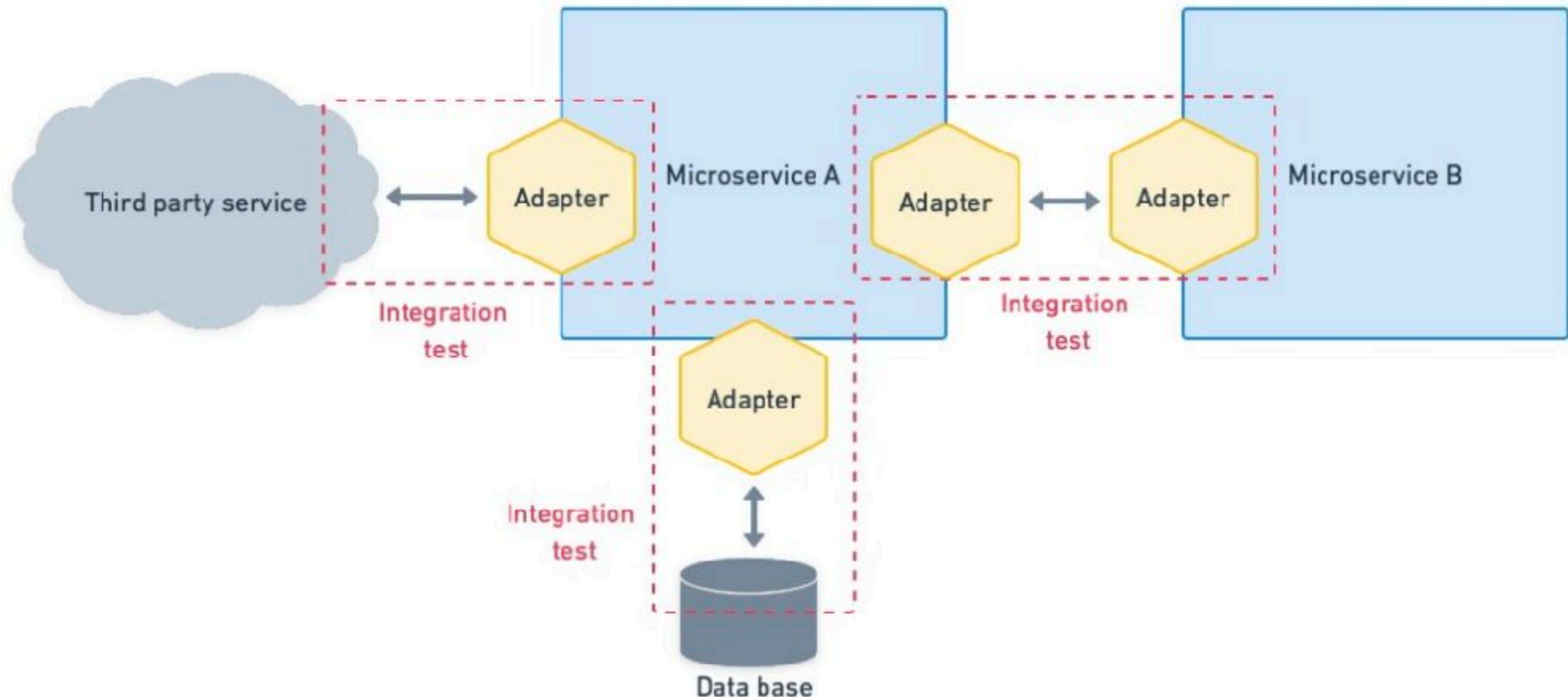
Sociable testing



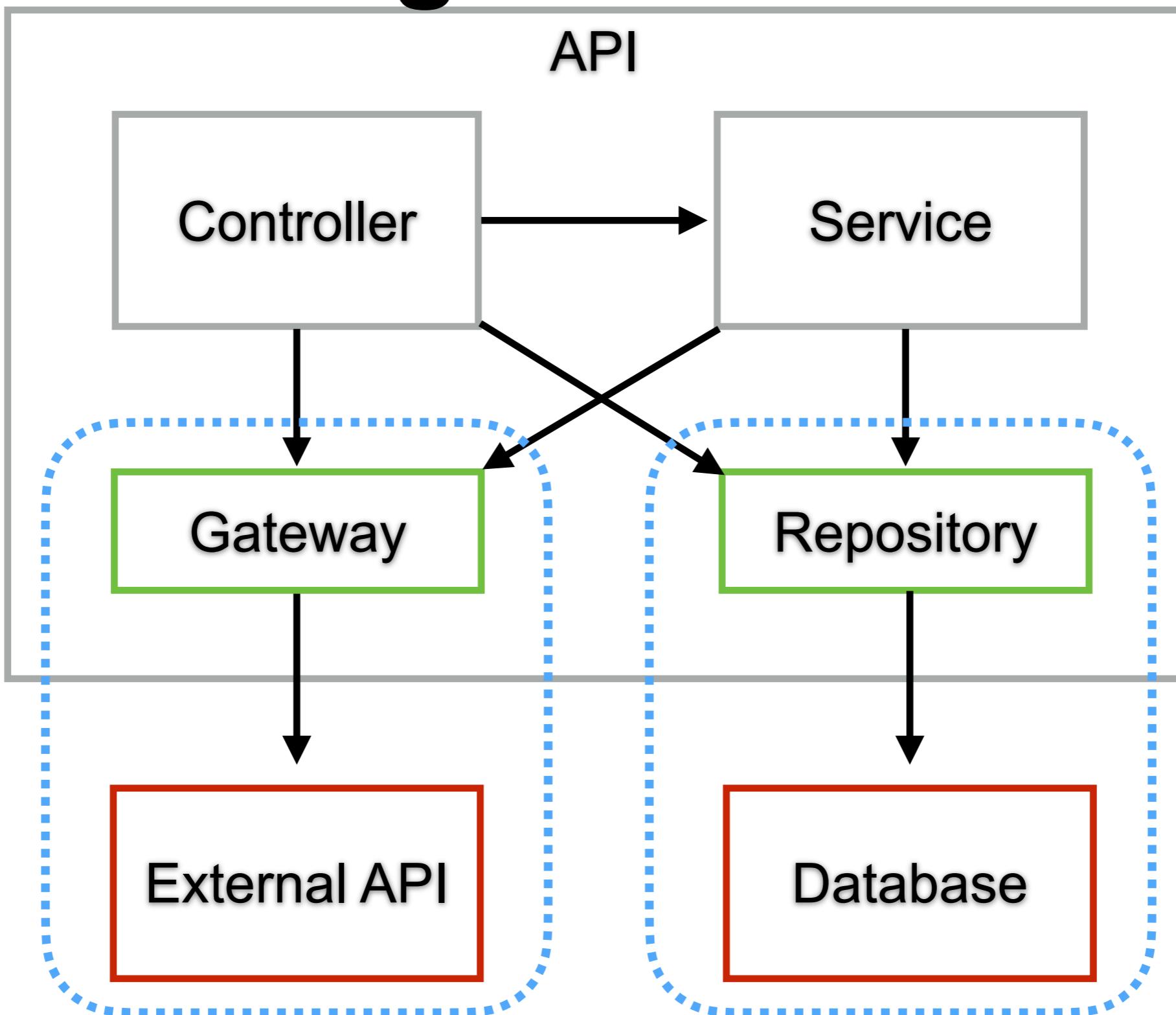
Unit test



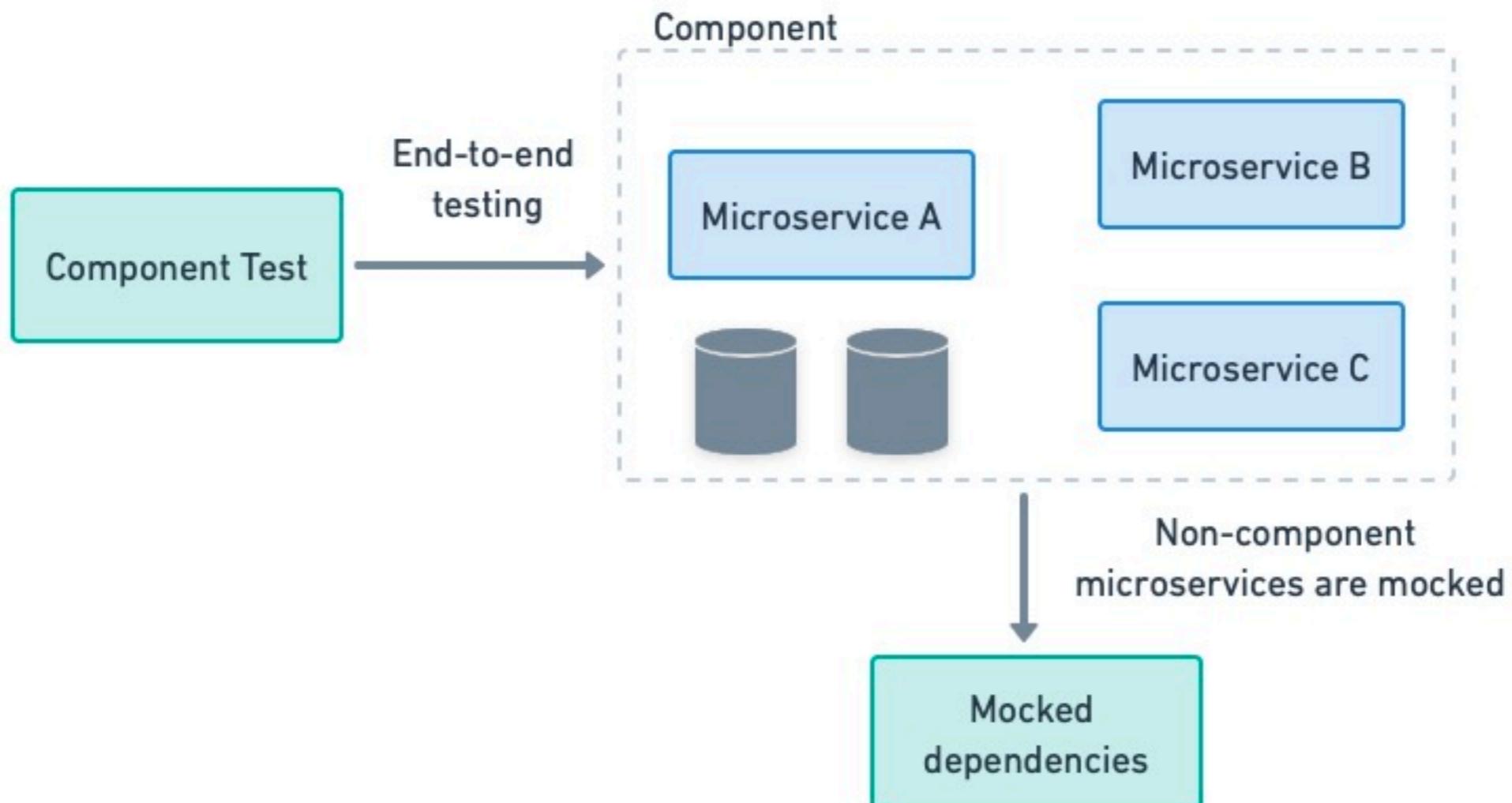
Integration test



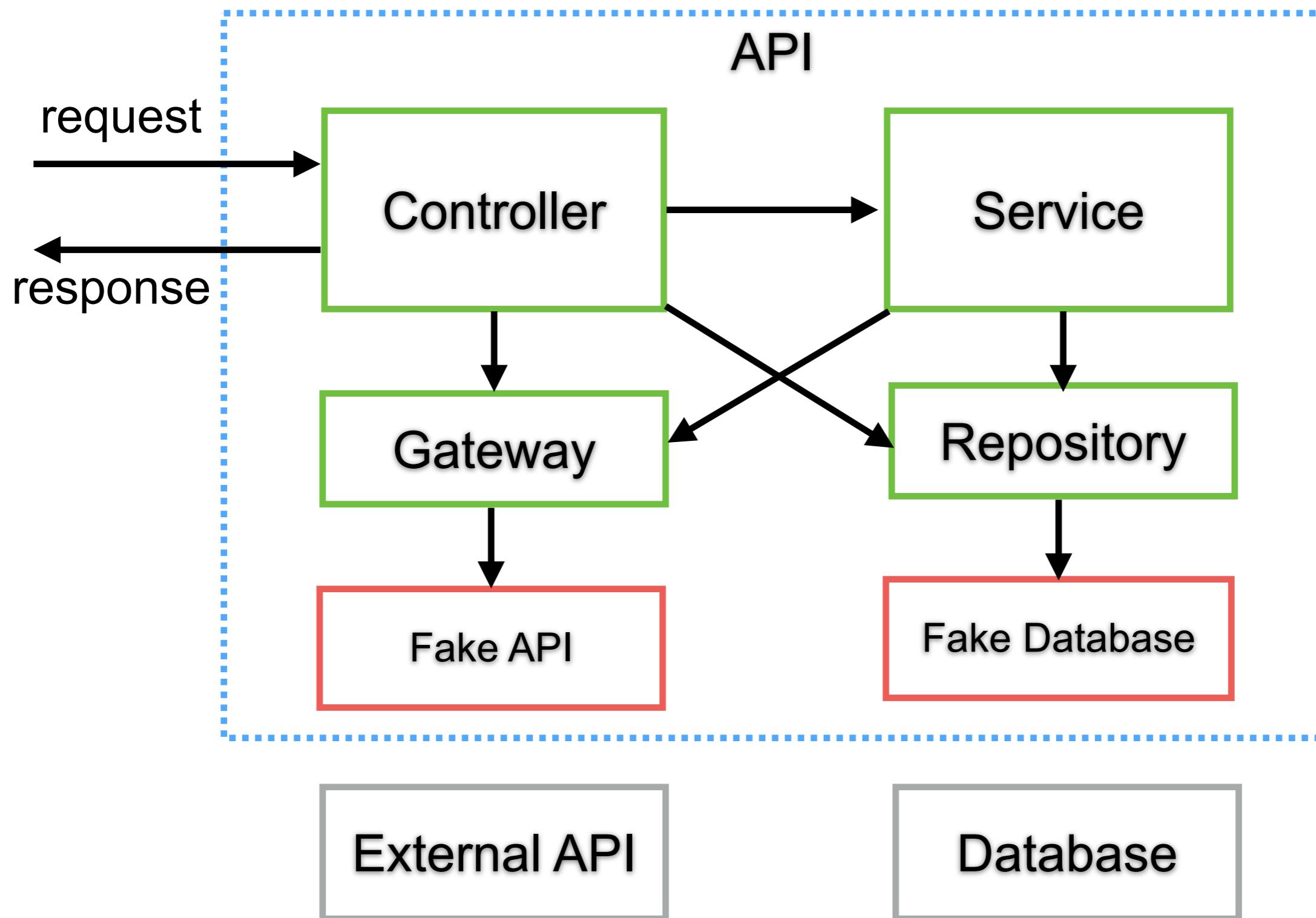
Integration test



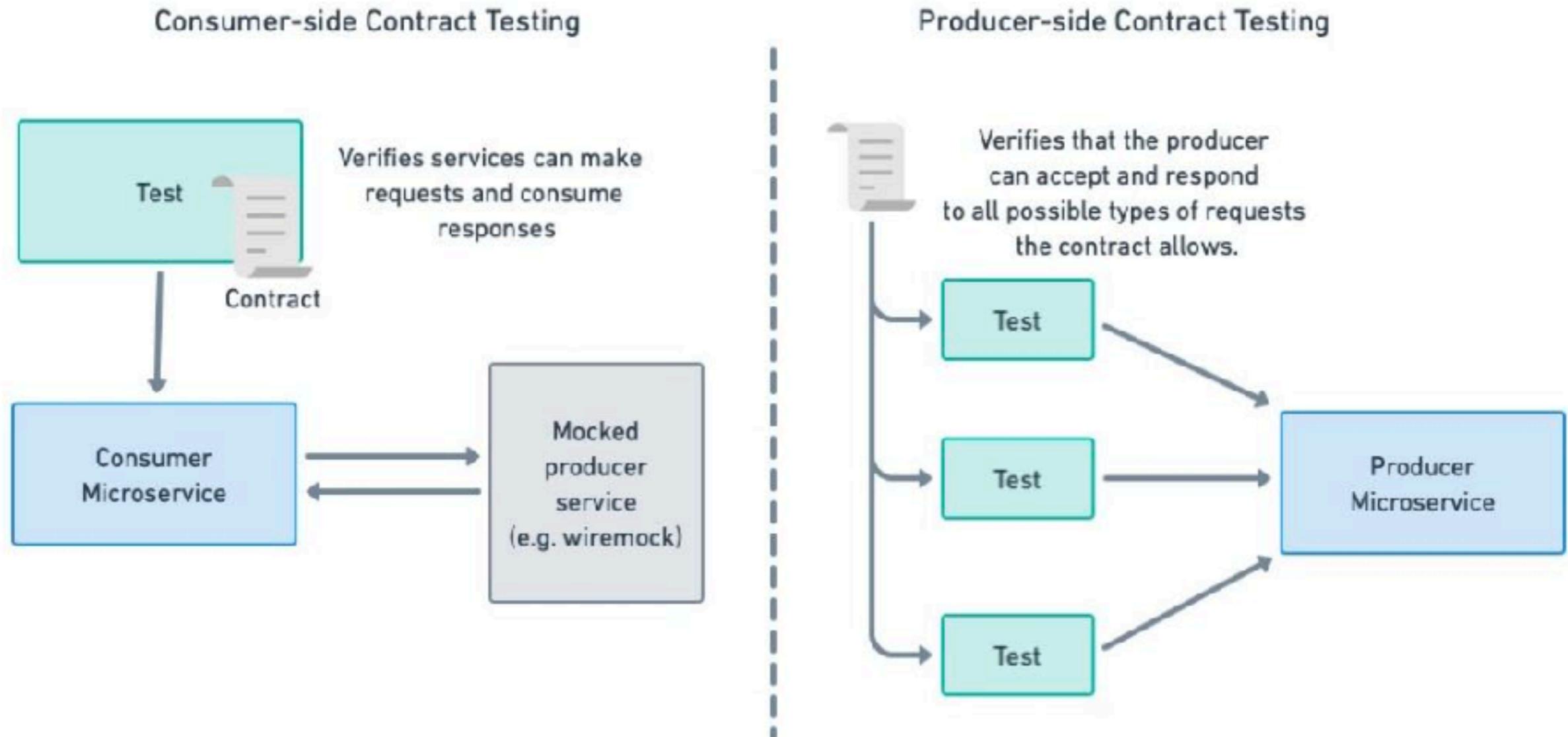
Component test



Component test



Contract test



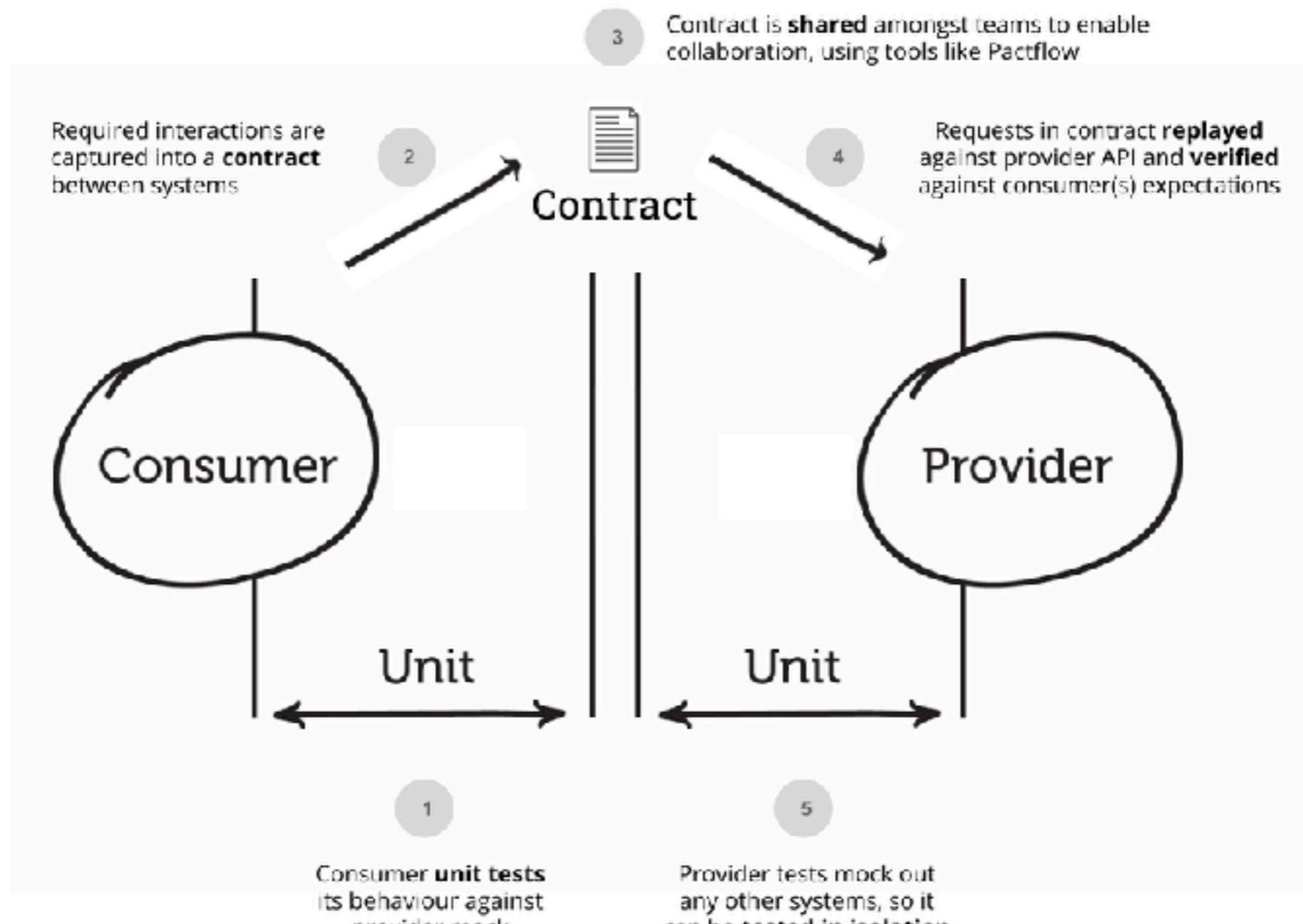
Contract test

Consumer-side contracts test

Provider-side contract test



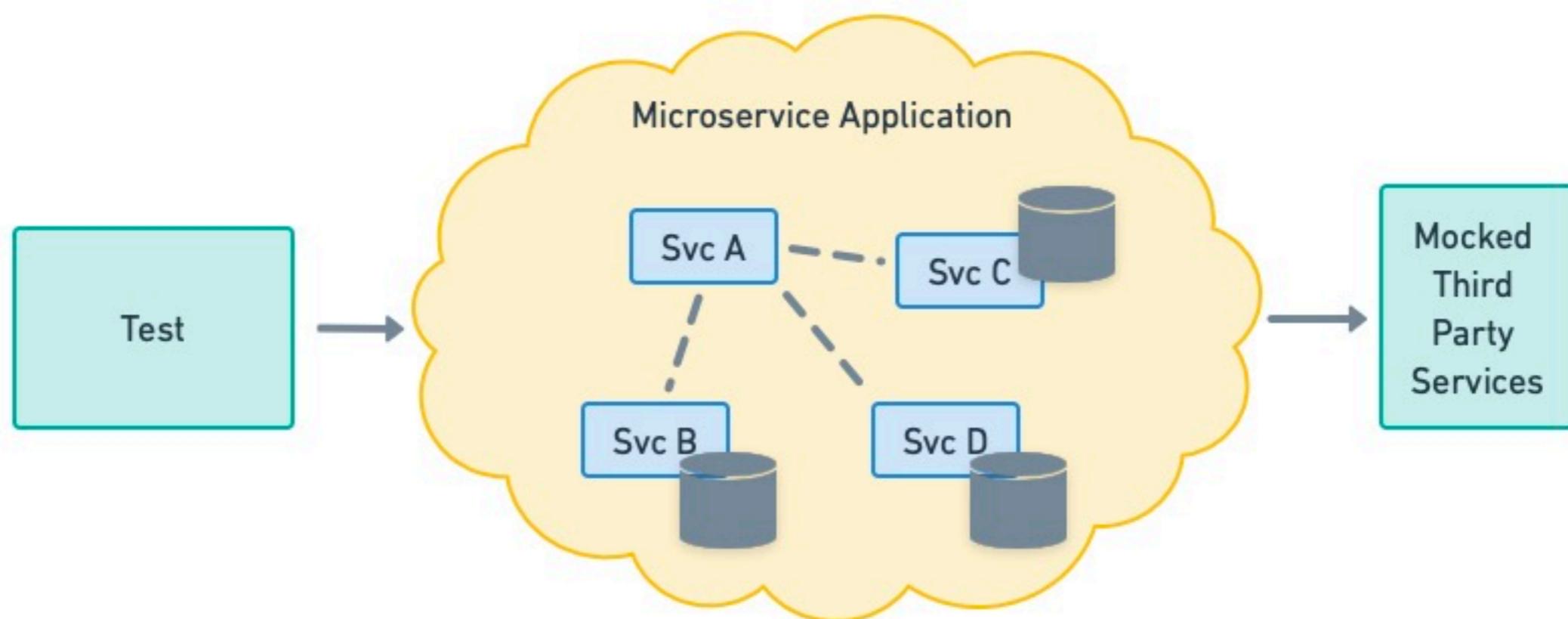
Contract test



<https://docs.pact.io/>



End-to-End test

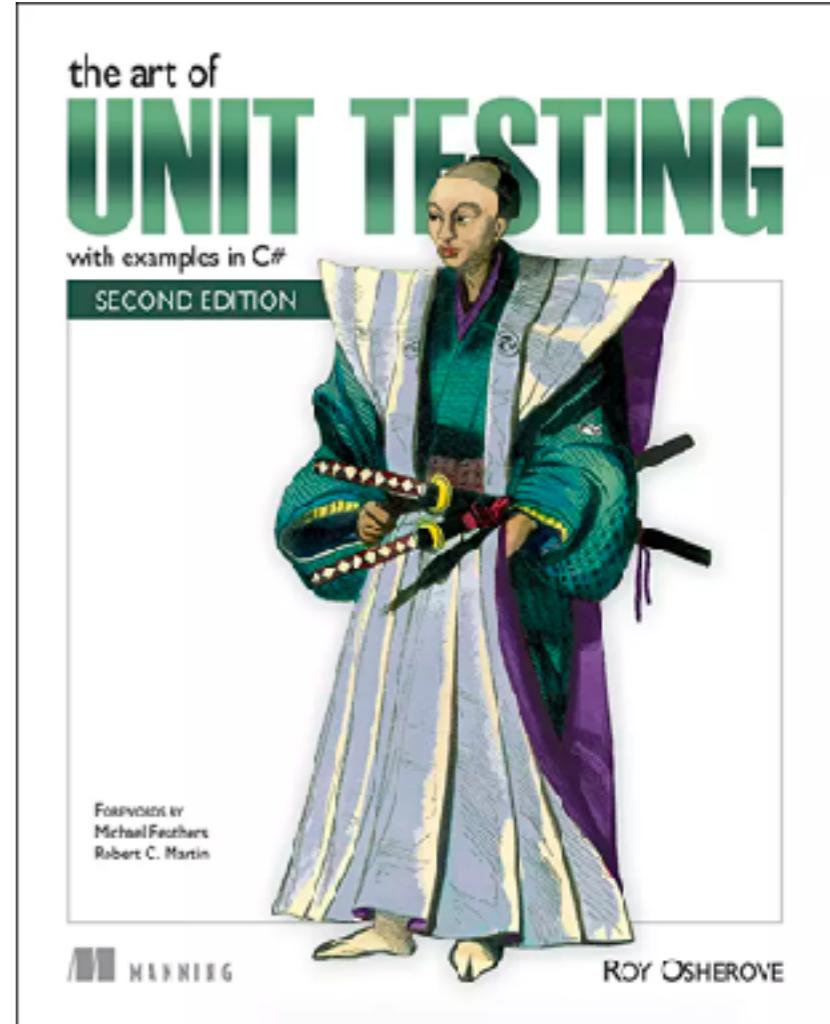
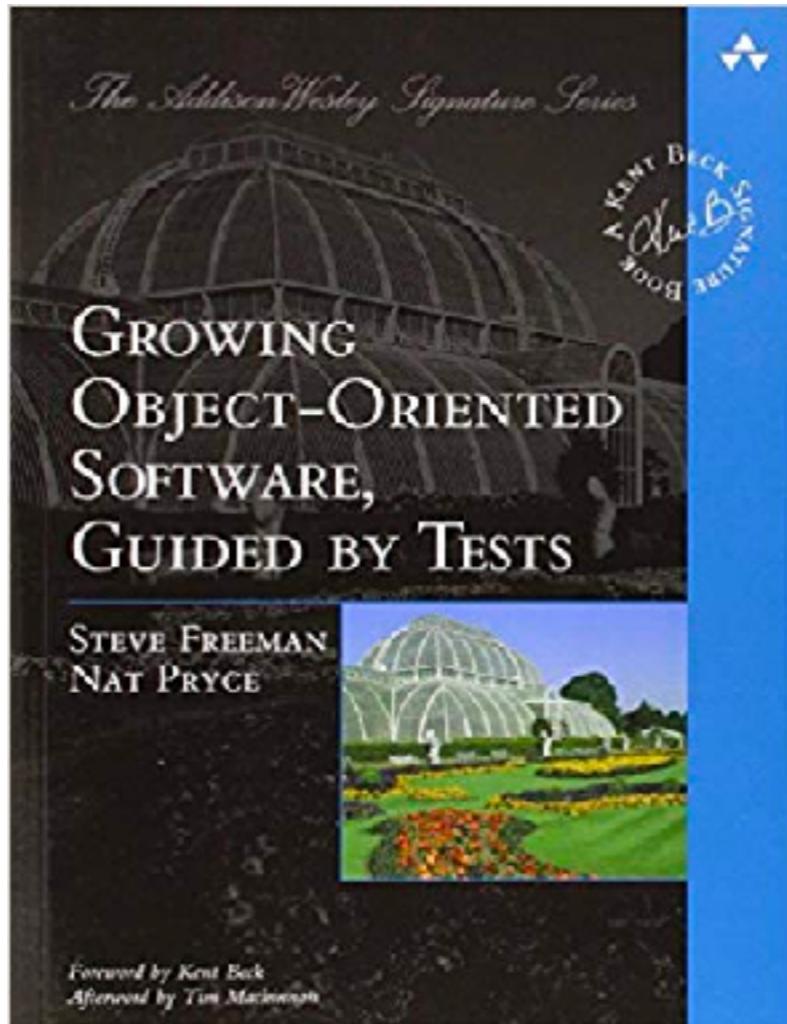
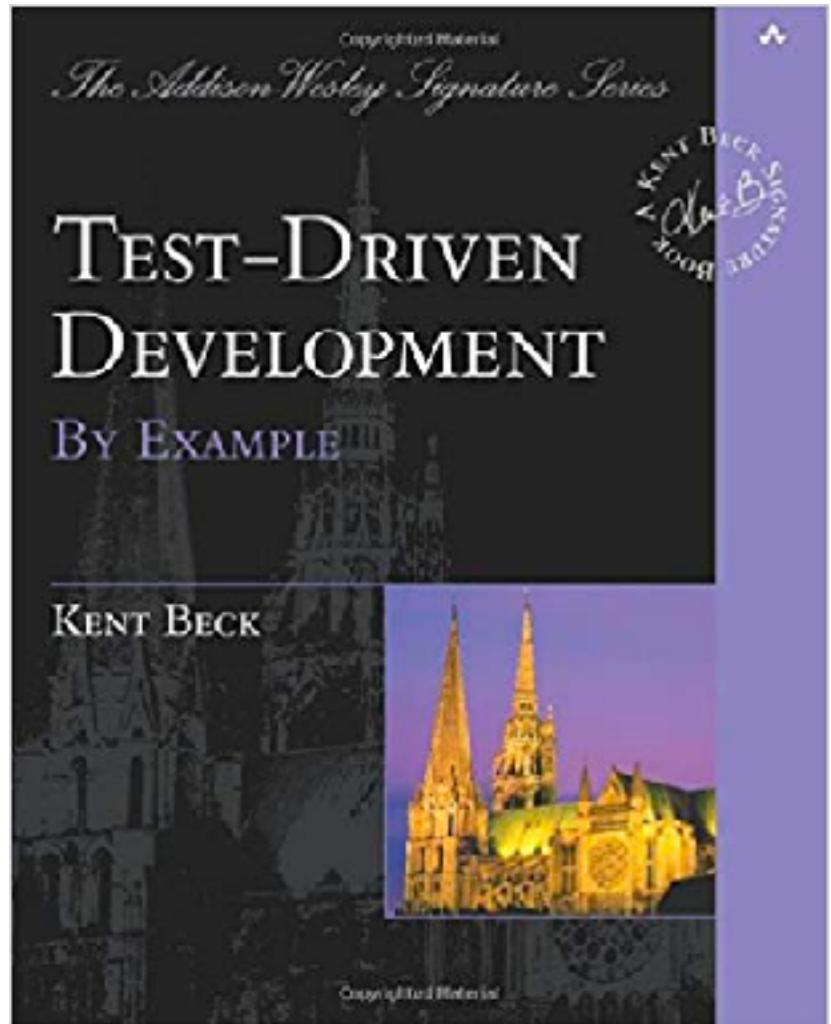


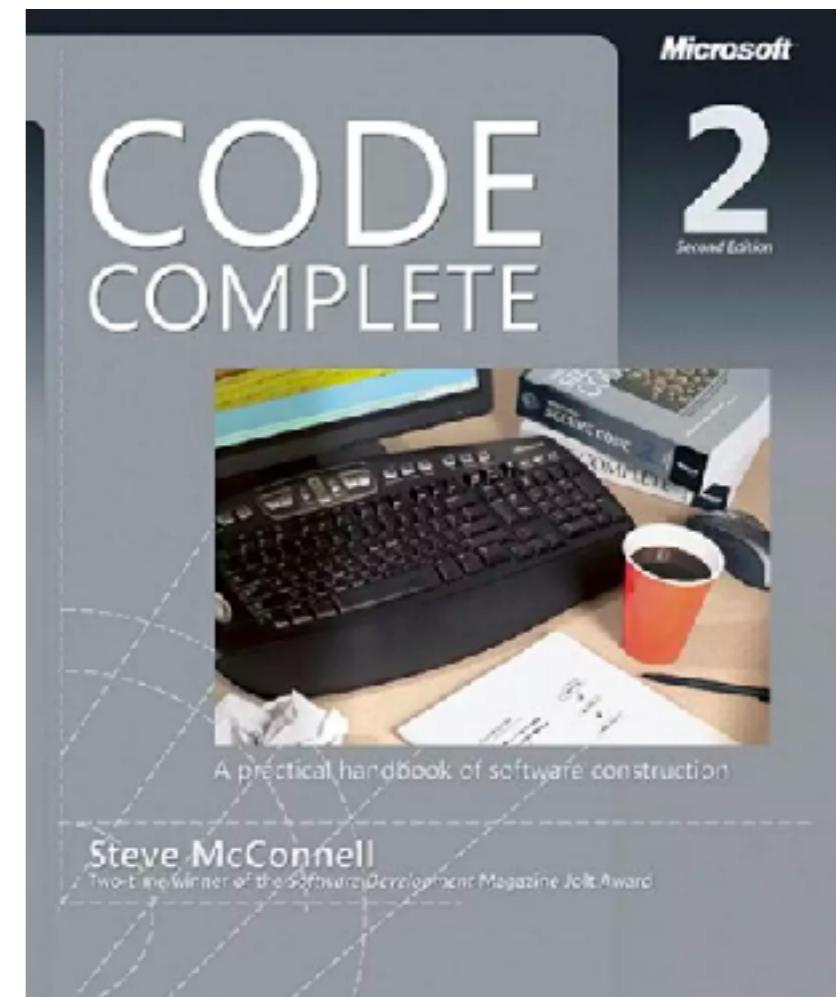
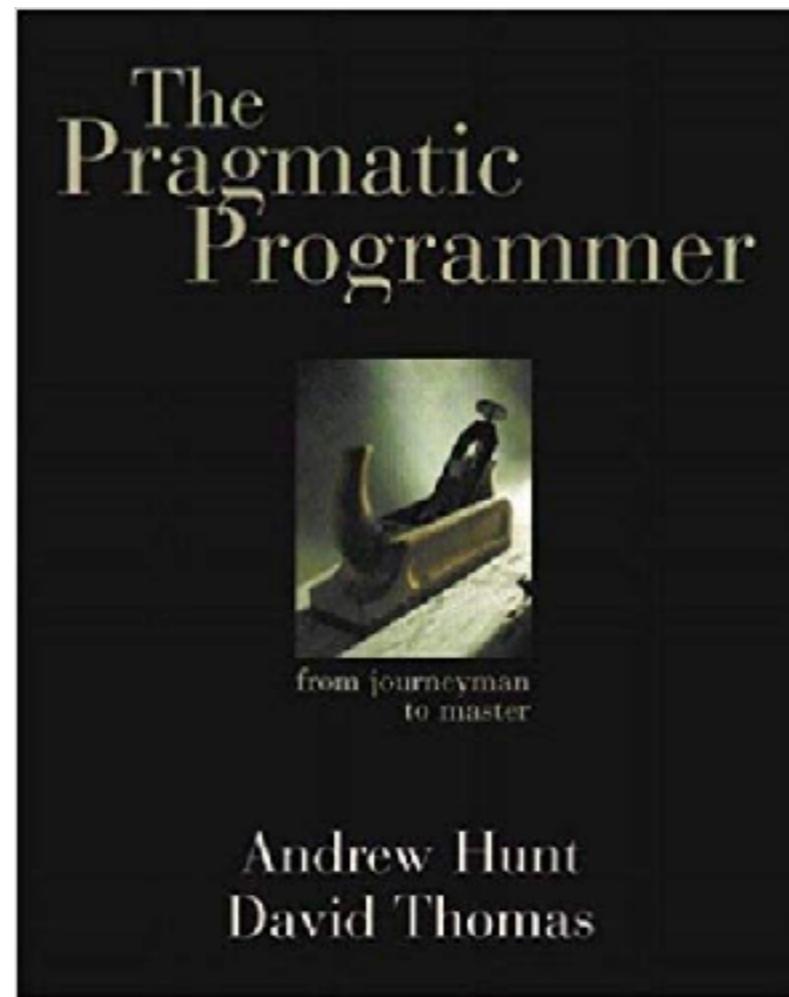
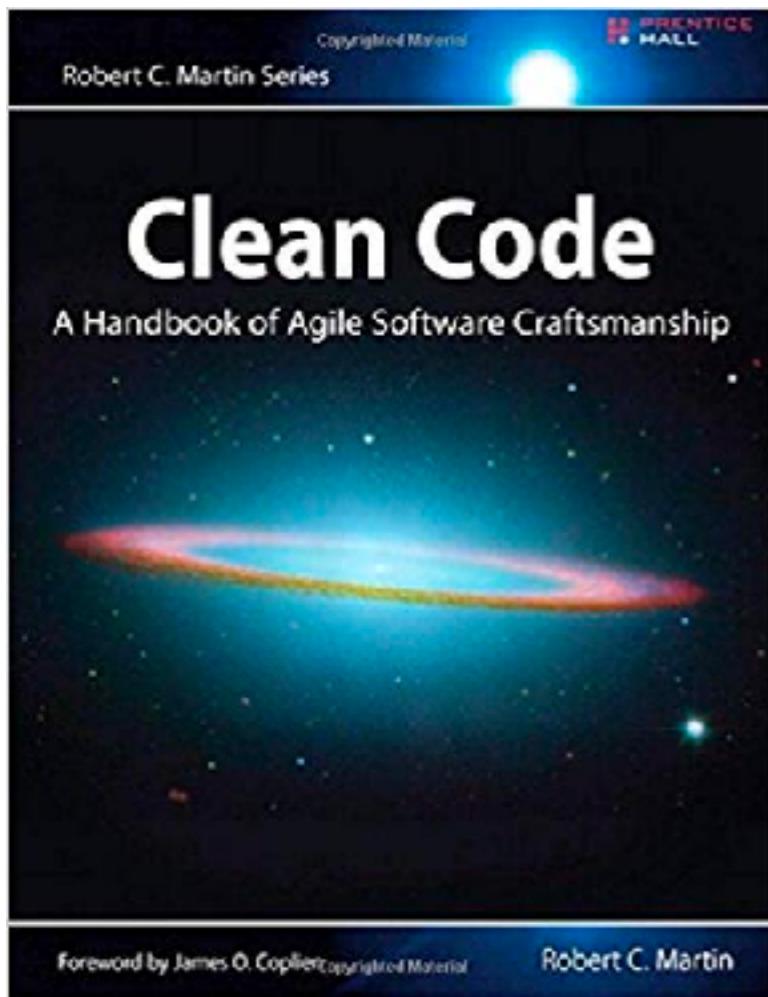
Workshop with REST API

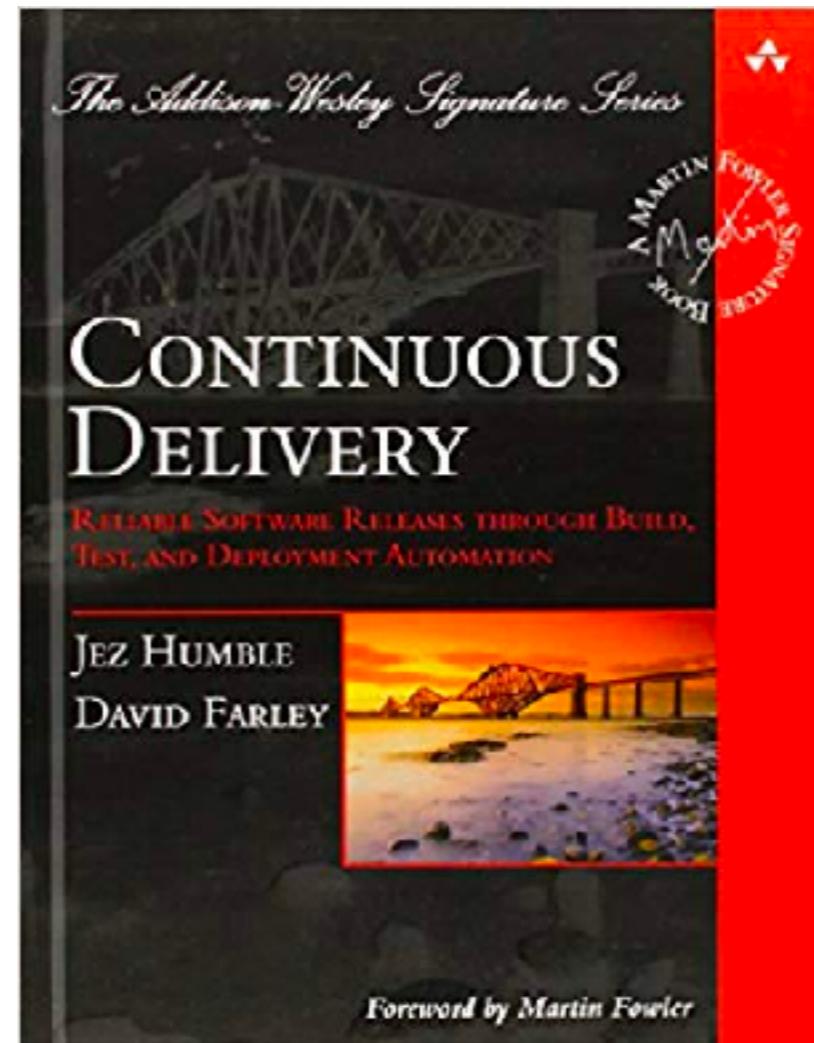
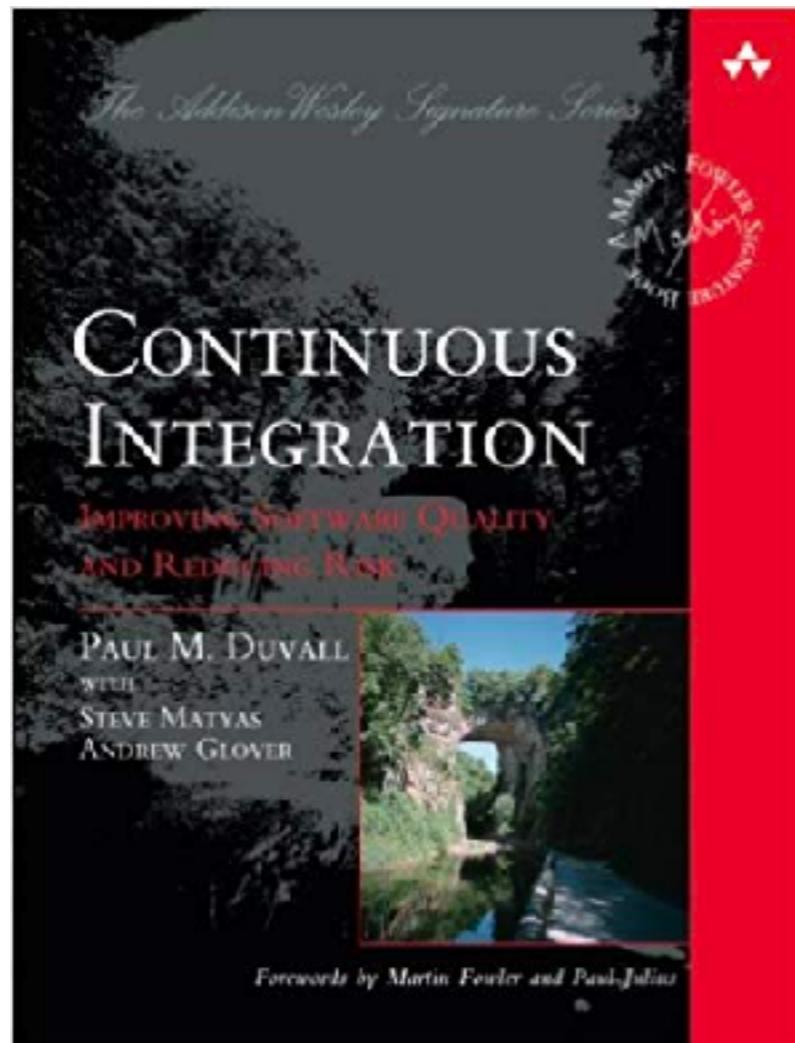


Books









Q/A

